April 27, 1948. R. H. LAWSON 2,440,280

KNITTING MACHINE AND METHOD OF KNITTING

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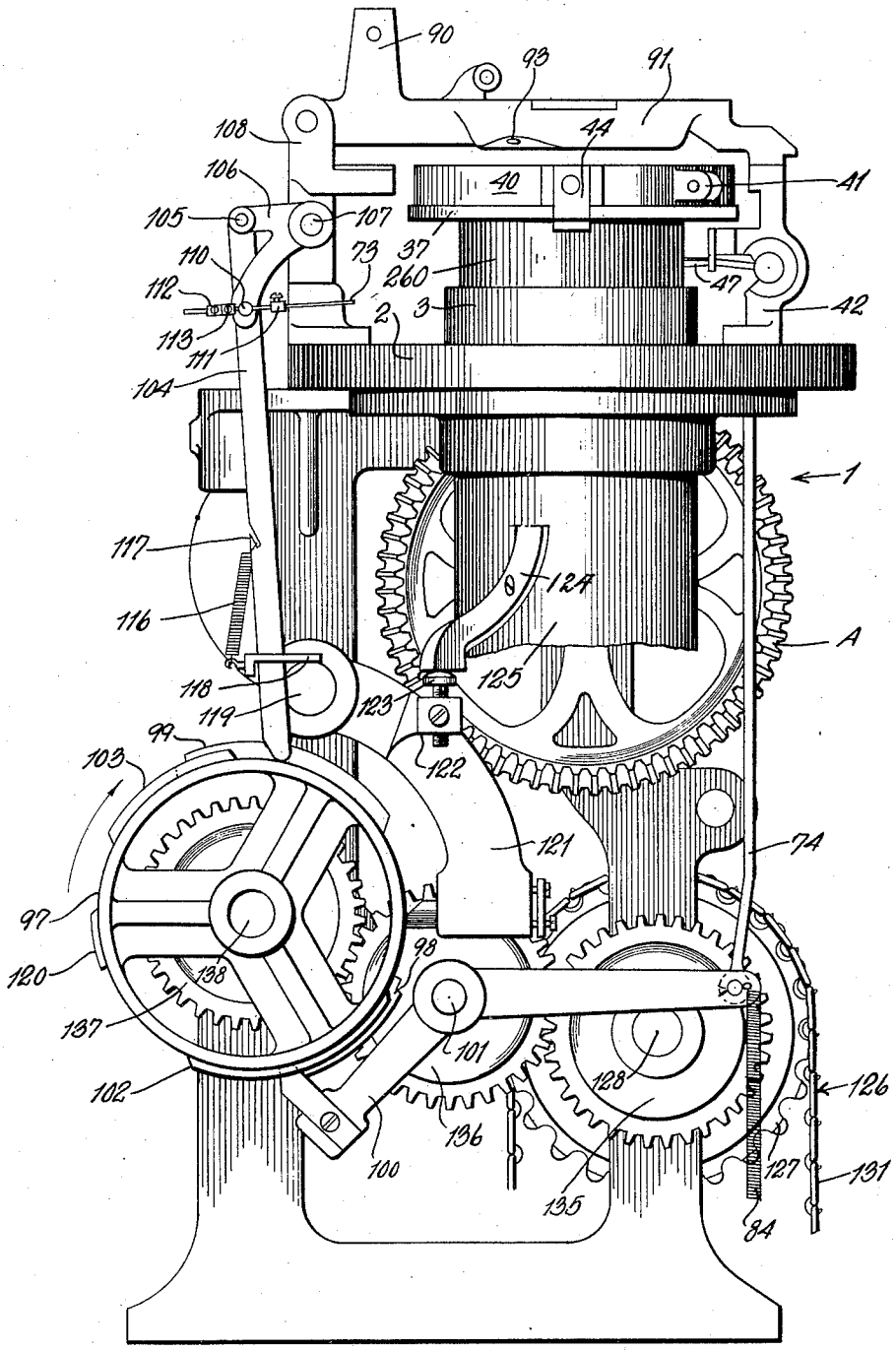

Fig. 1.

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KNITTING MACHINE AND METHOD OF KNITTING

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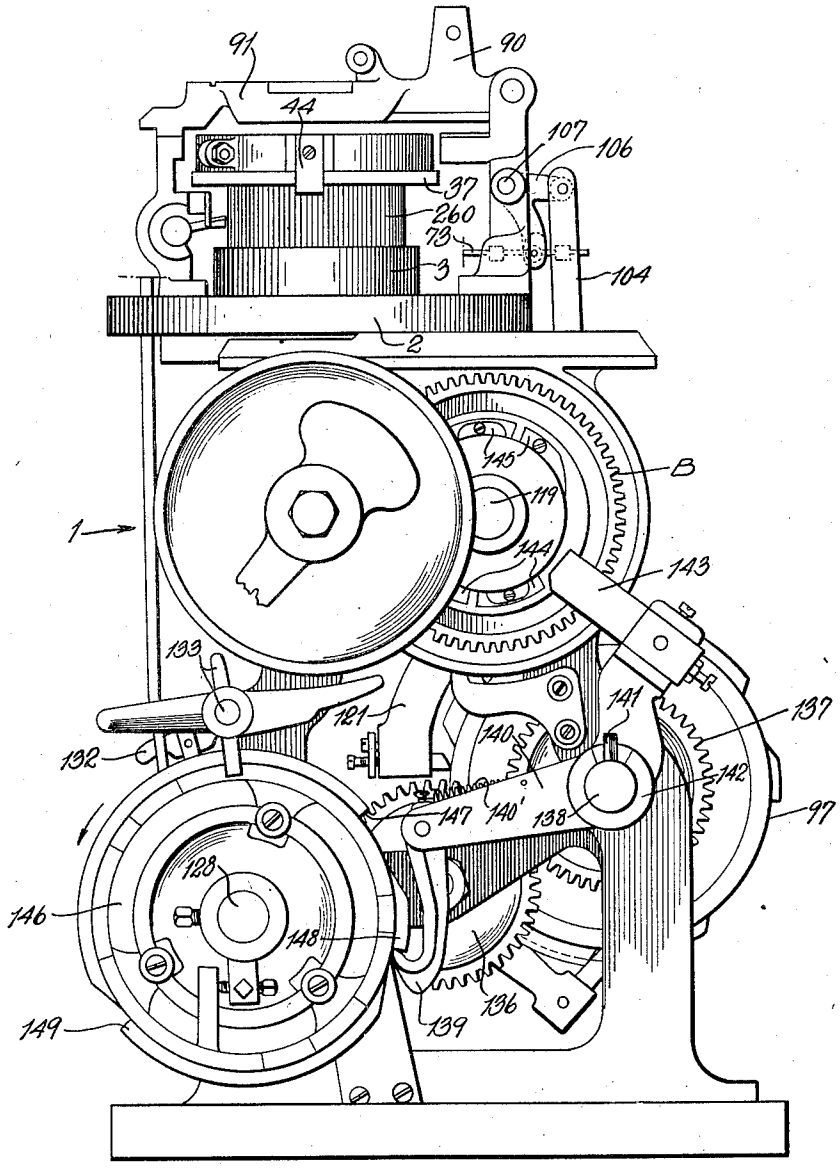
Fig. 2.



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KNITTING MACHINE AND METHOD OF KNITTING

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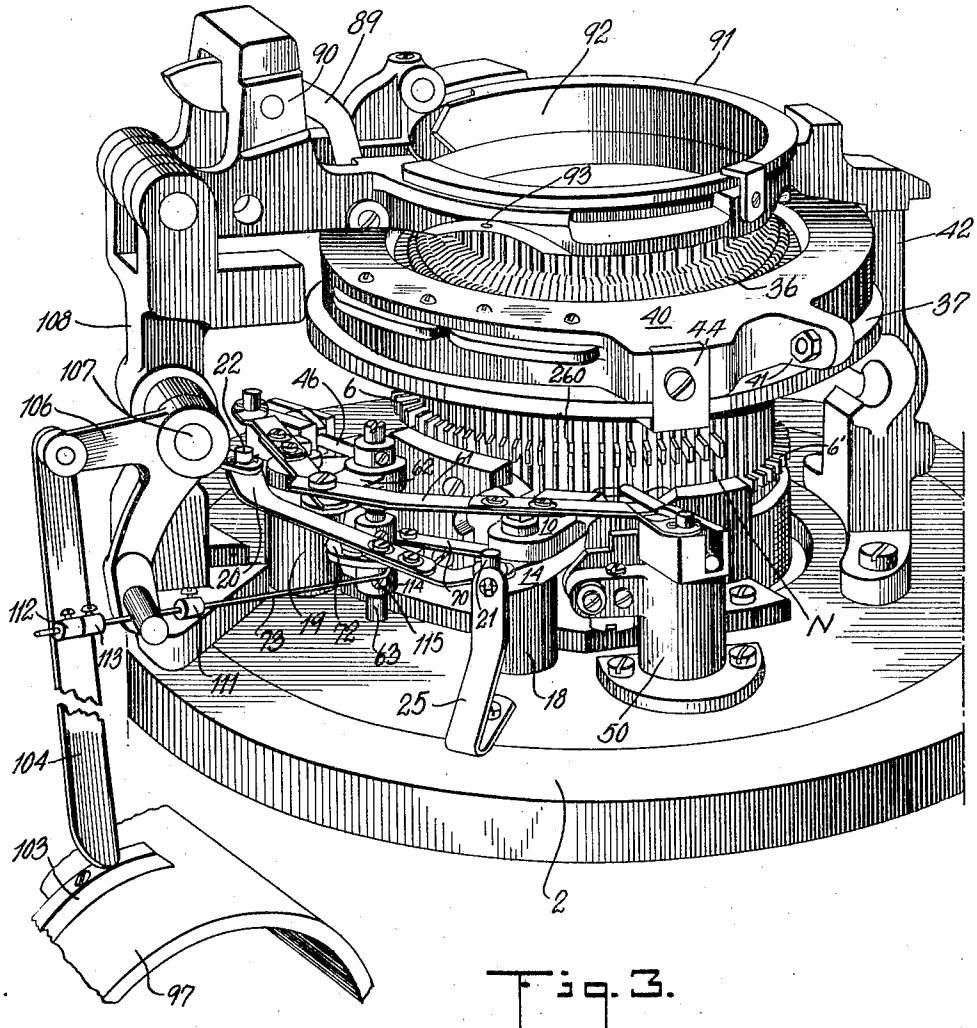

Fig. 3.

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KNITTING MACHINE AND METHOD OF KNITTING

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Fig. 4.

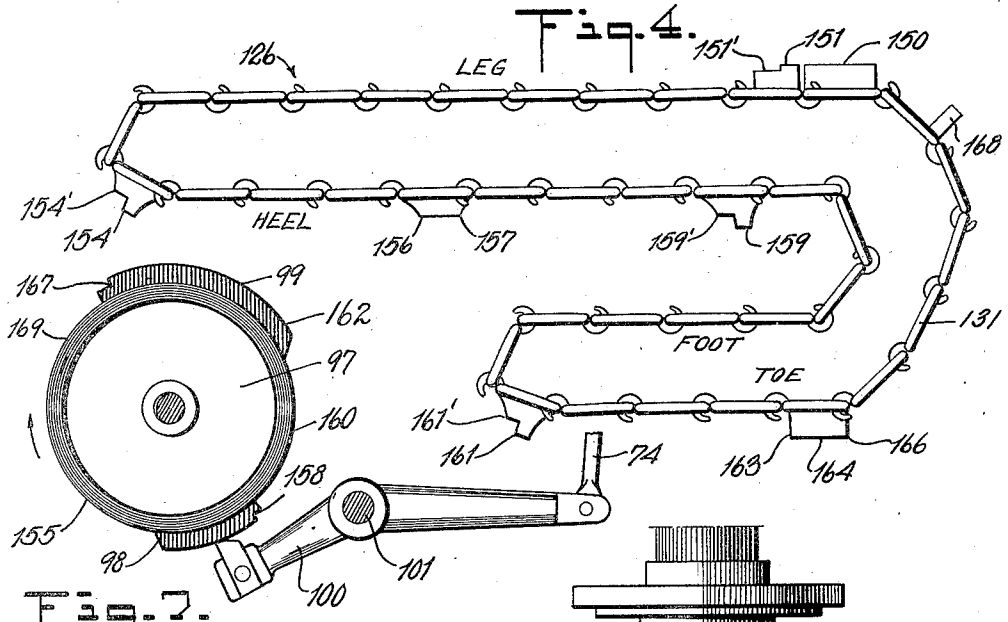
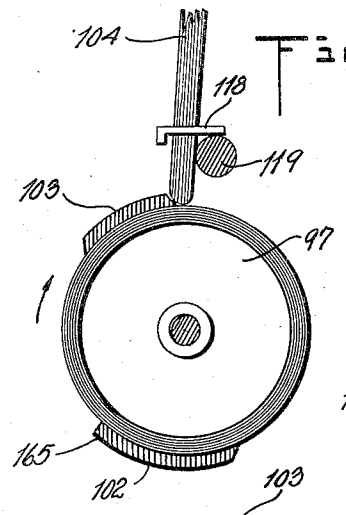


Fig. 7.

Fig. 6.



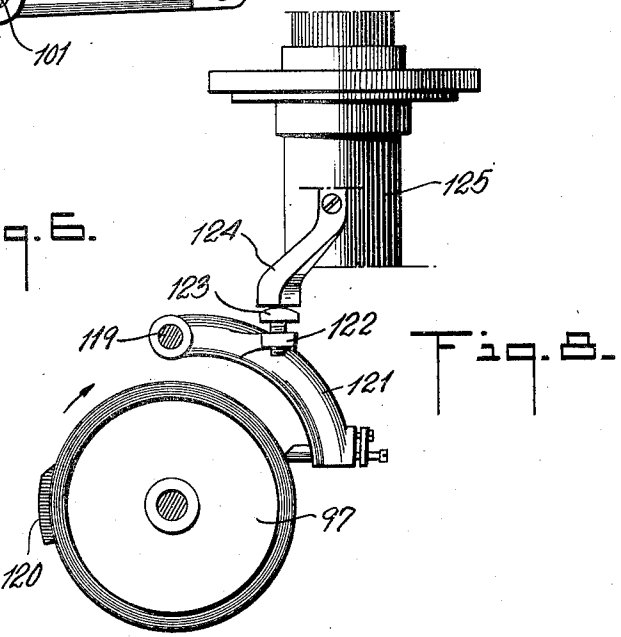


Fig. 8.

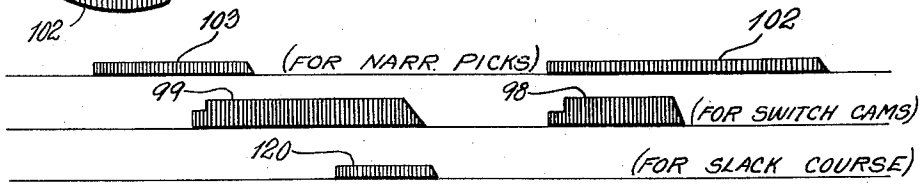


Fig. 5.

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KNITTING MACHINE AND METHOD OF KNITTING

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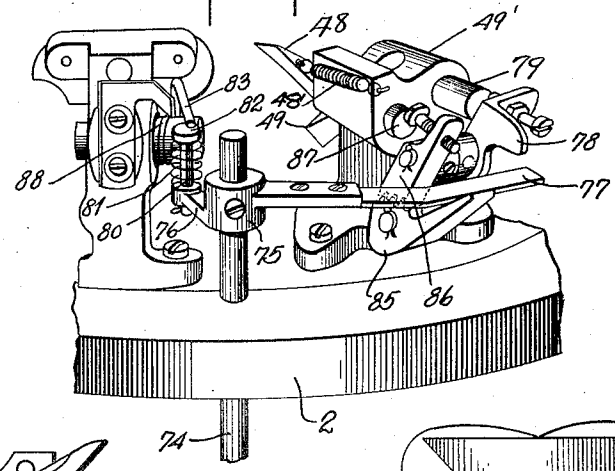
Fig. 23.



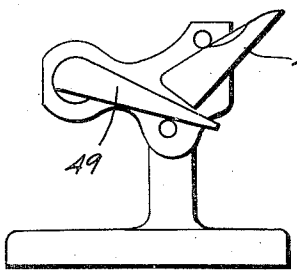


Fig. 24.

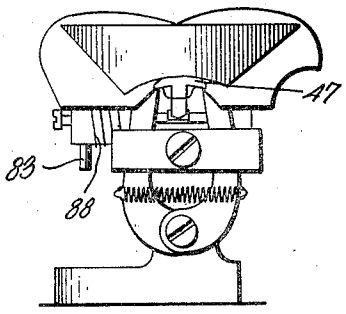


Fig. 25.

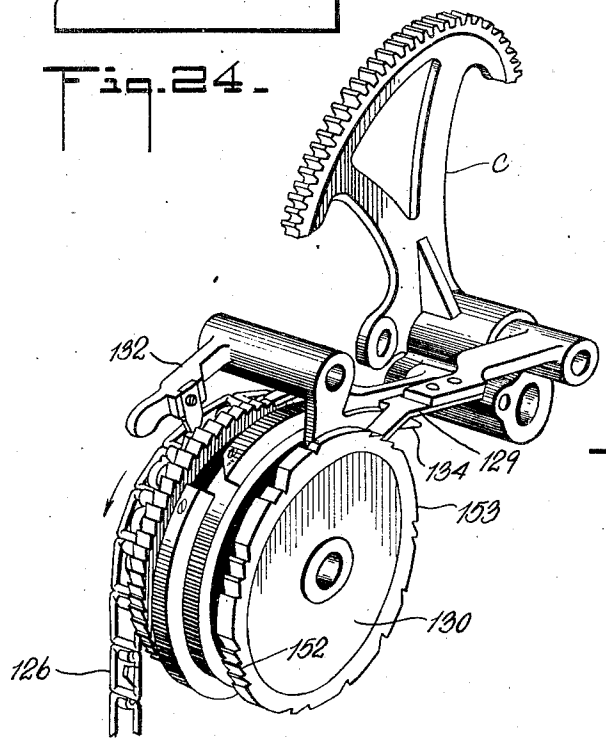


Fig. 8.

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KNITTING MACHINE AND METHOD OF KNITTING

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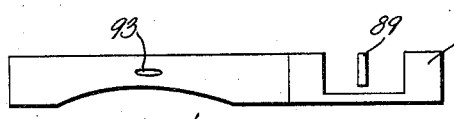

Fig. 10.

Fig. 11.

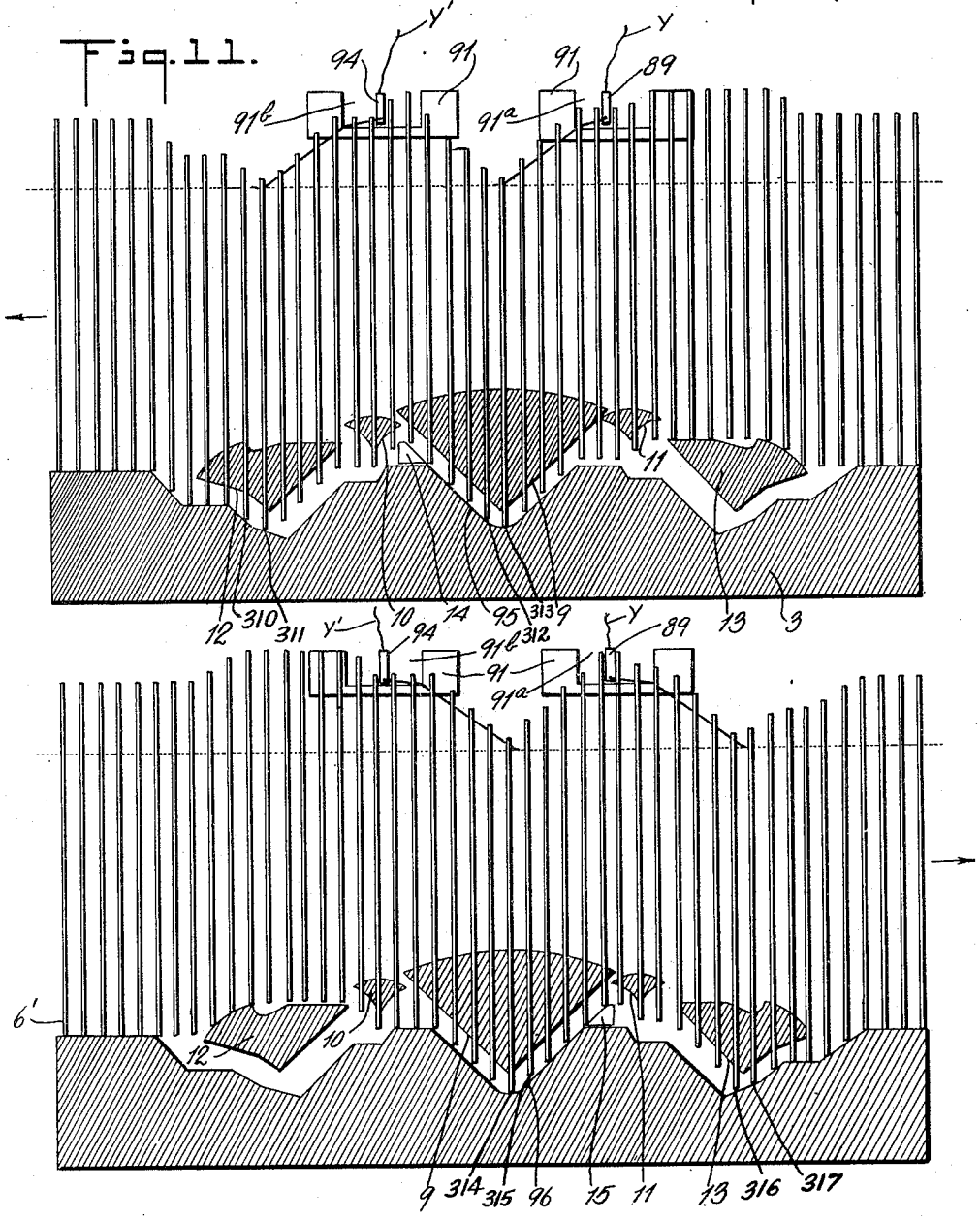

Fig. 12.

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KNITTING MACHINE AND METHOD OF KNITTING

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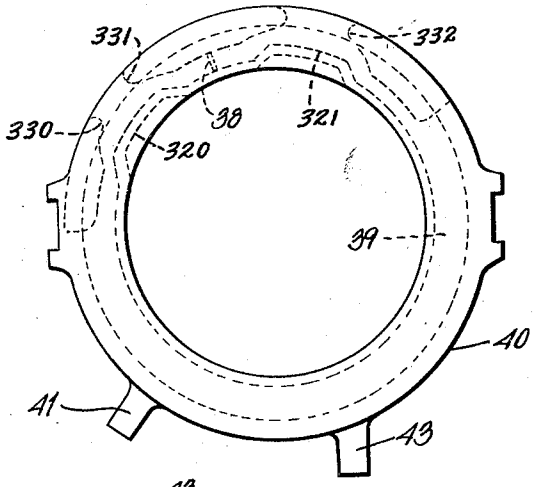

Fig. 13.

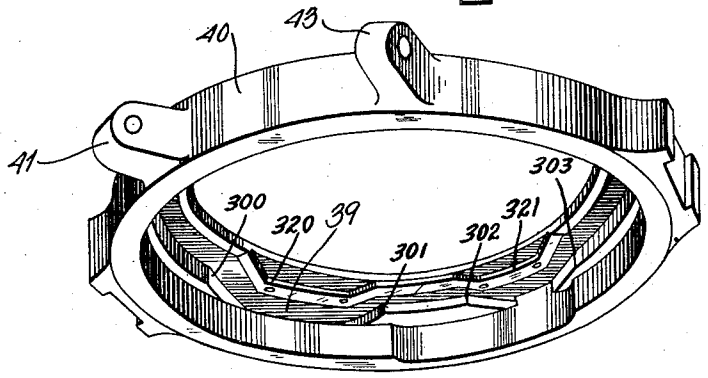

Fig. 14.

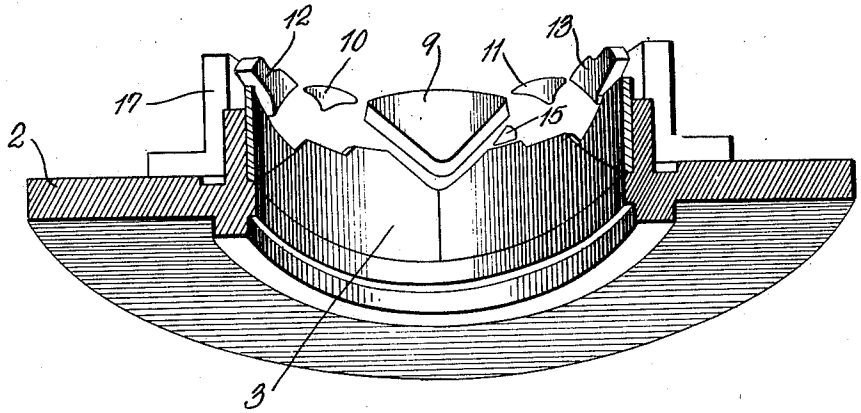

Fig. 15.

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KNITTING MACHINE AND METHOD OF KNITTING

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Fig. 16.

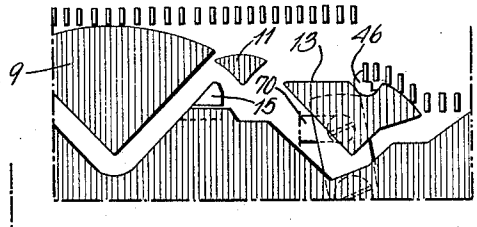
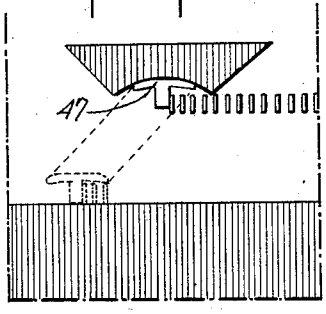


Fig. 21.



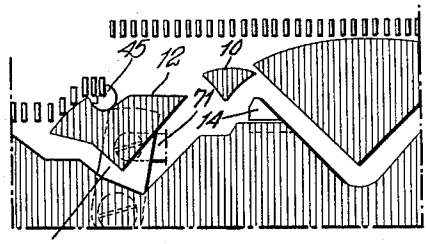


Fig. 17.

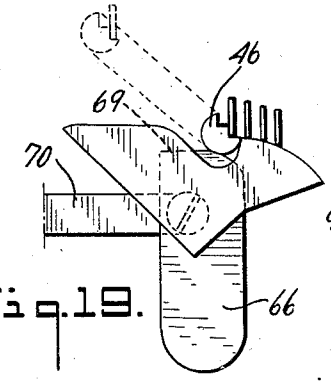


Fig. 19.

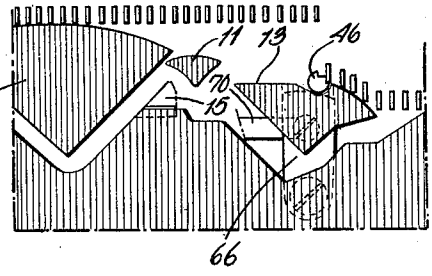


Fig. 18.

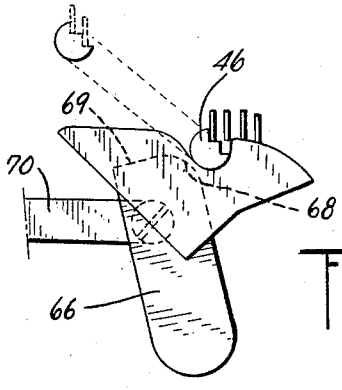


Fig. 20.

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KNITTING MACHINE AND METHOD OF KNITTING

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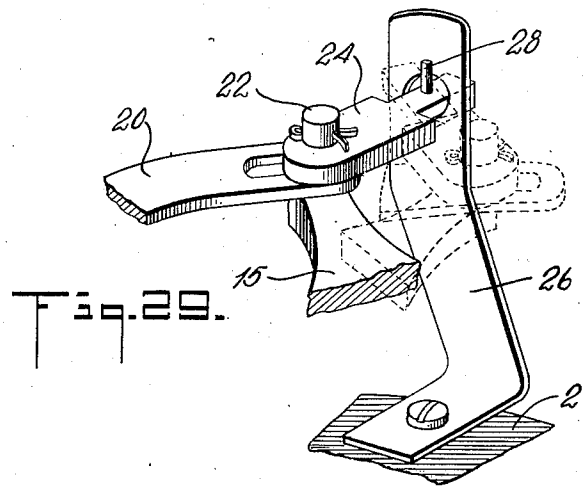

Fig. 29.

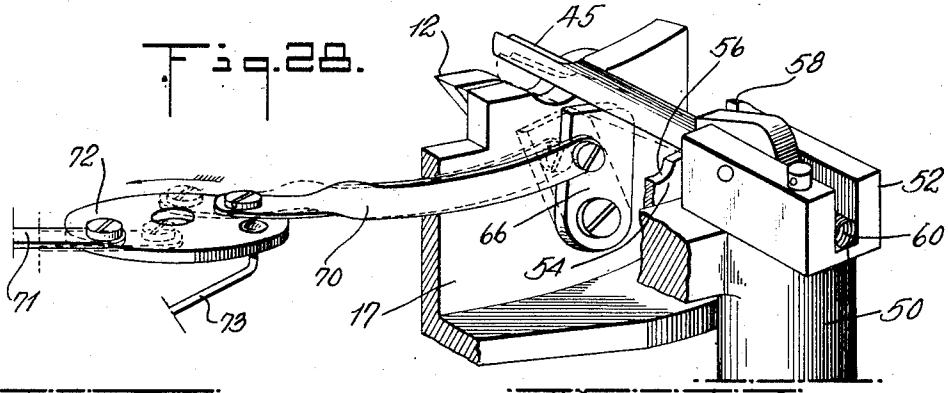

Fig. 28.

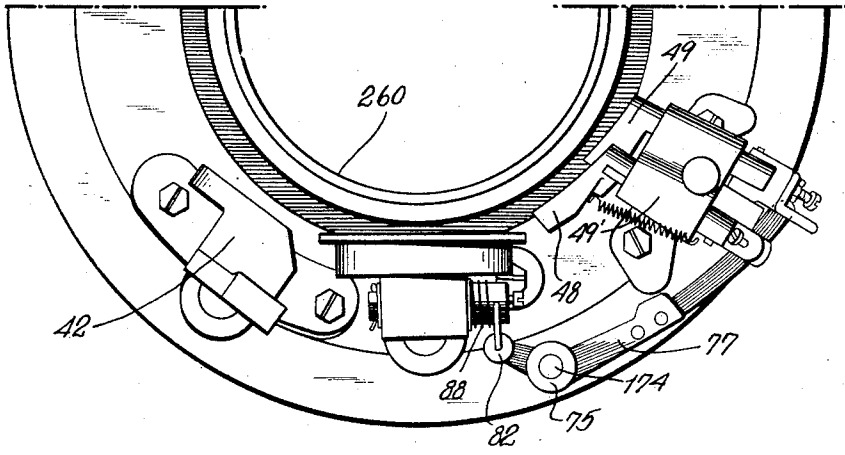

Fig. 22.

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KNITTING MACHINE AND METHOD OF KNITTING

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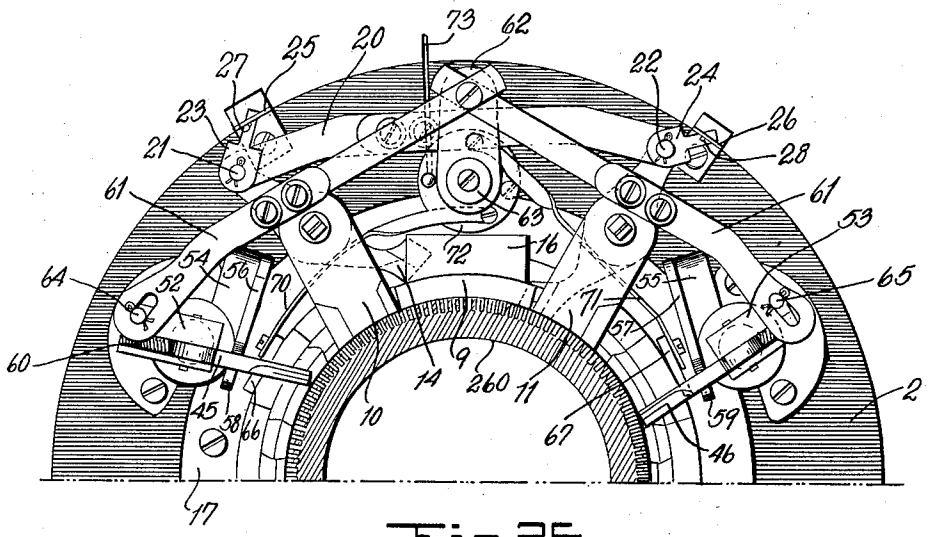

Fig. 26.

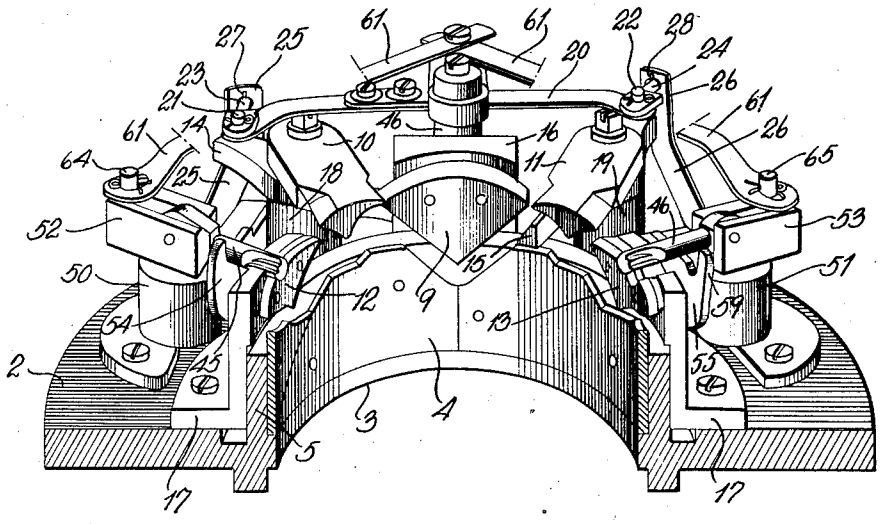

Fig. 27.

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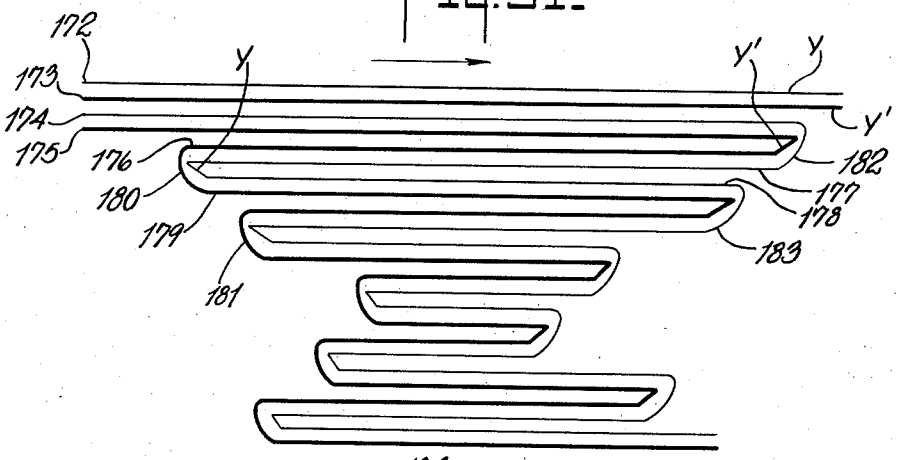
Fig. 31.



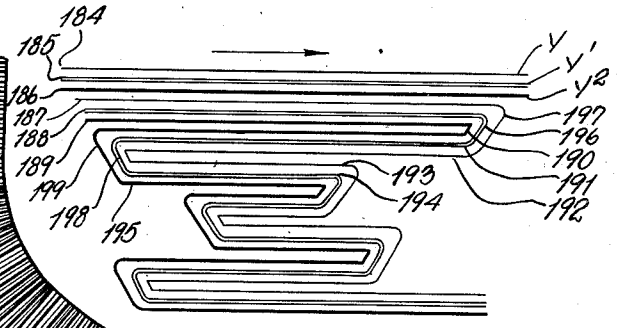


Fig. 32.

Fig. 30.

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KNITTING MACHINE AND METHOD OF KNITTING

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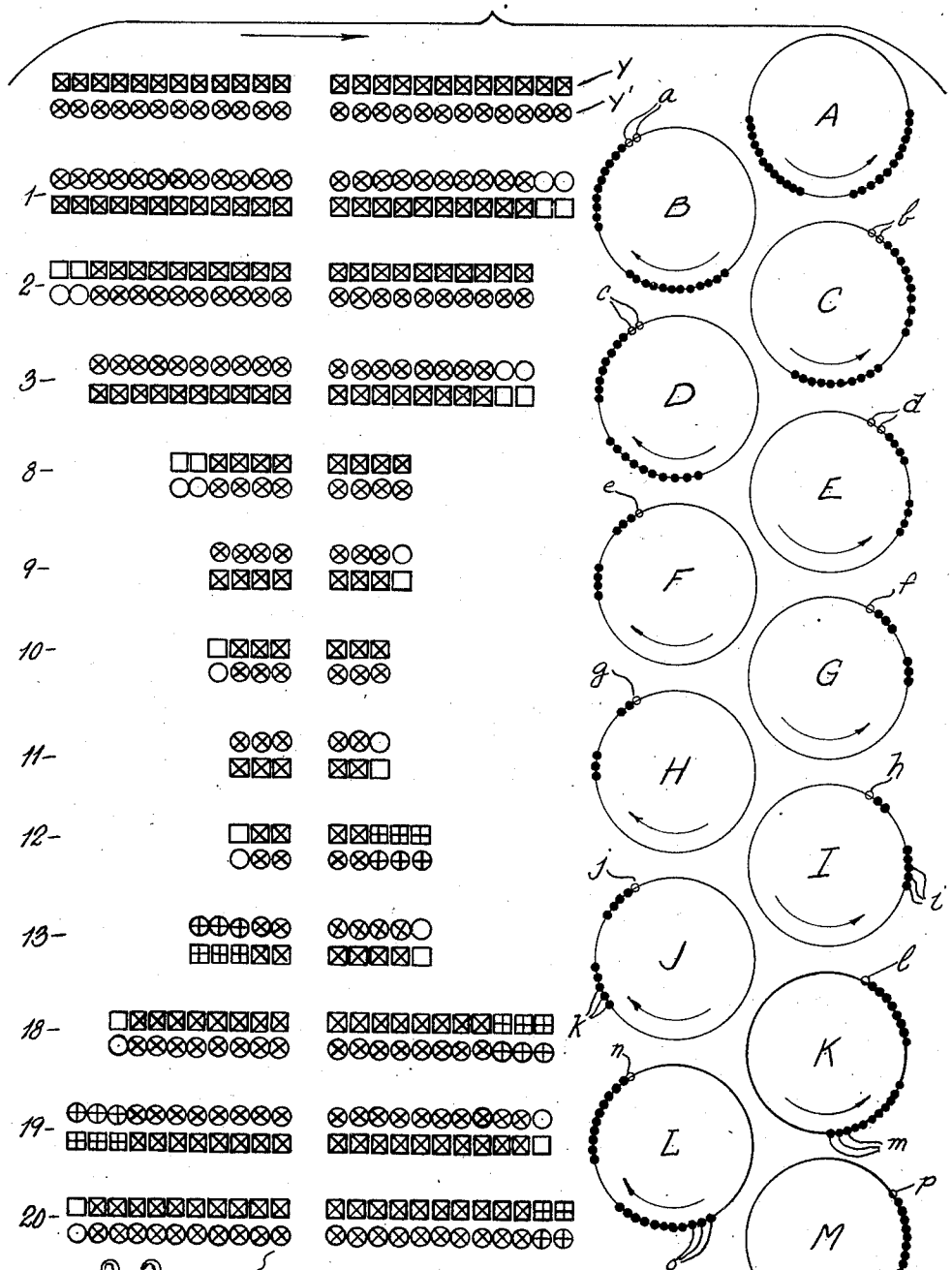

Fig. 33.

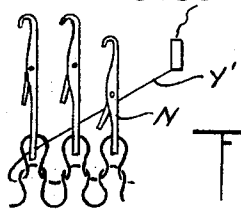

Fig. 34.

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KNITTING MACHINE AND METHOD OF KNITTING

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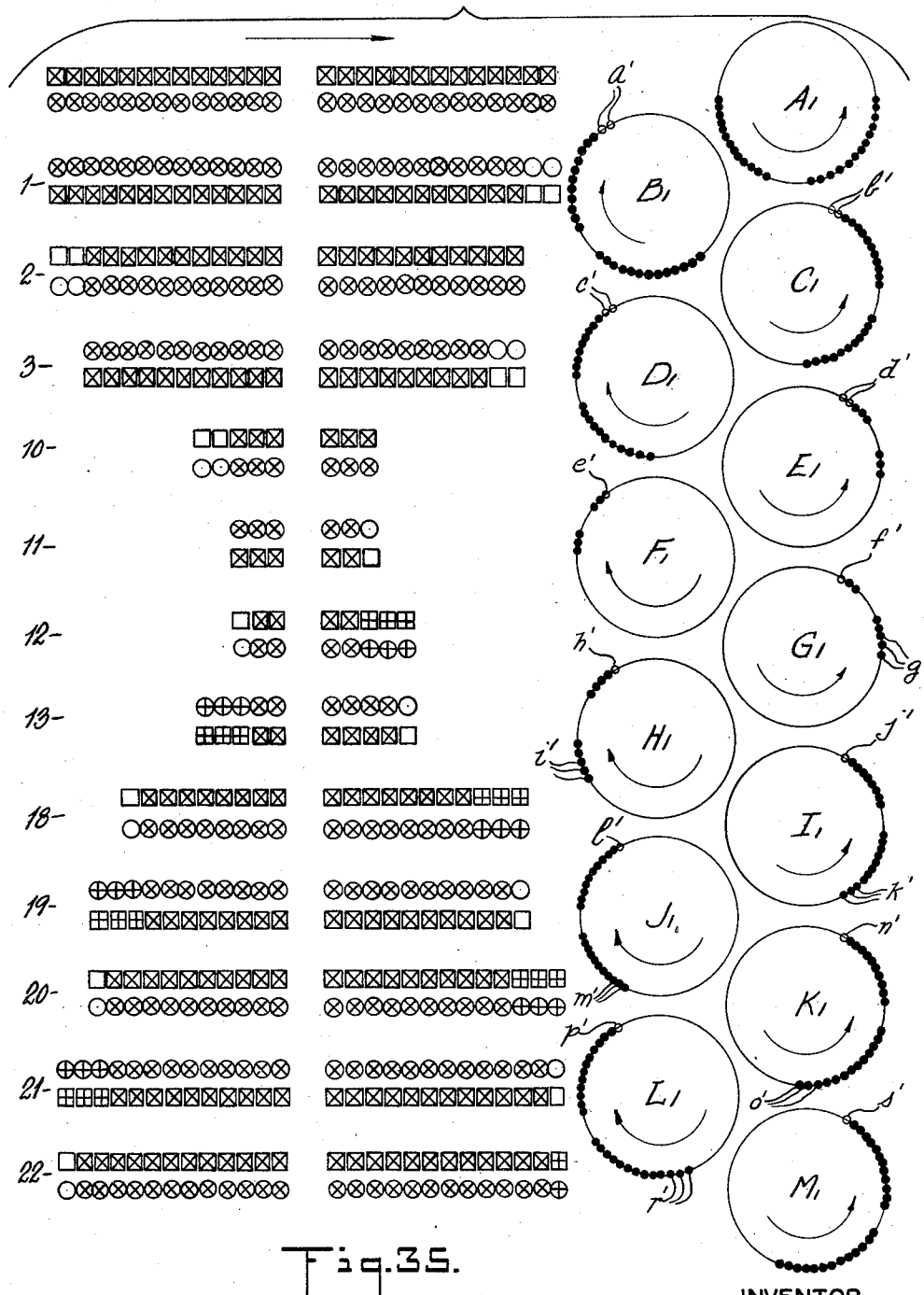

Fig. 35.

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KNITTING MACHINE AND METHOD OF KNITTING

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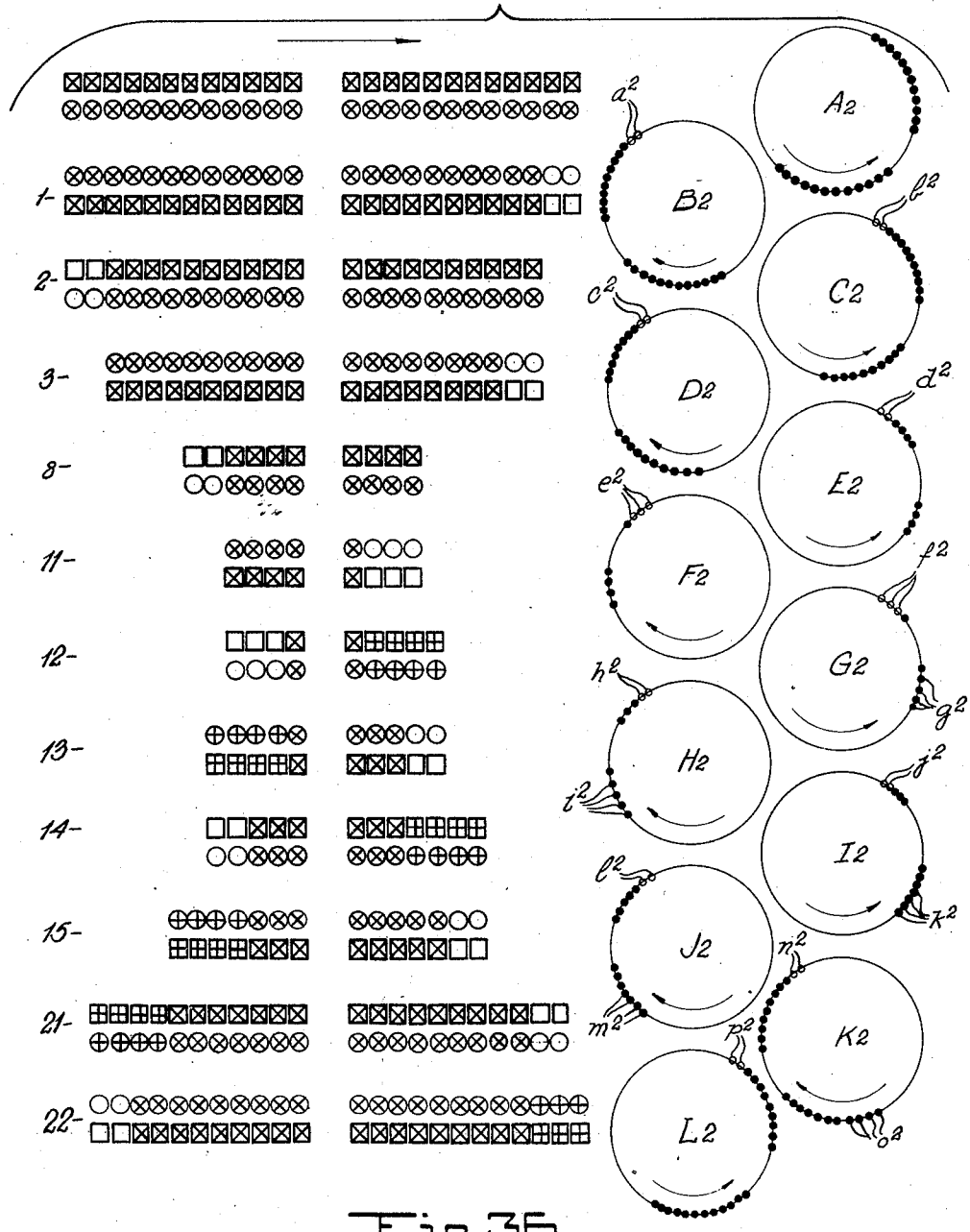

Fig. 36.

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KNITTING MACHINE AND METHOD OF KNITTING

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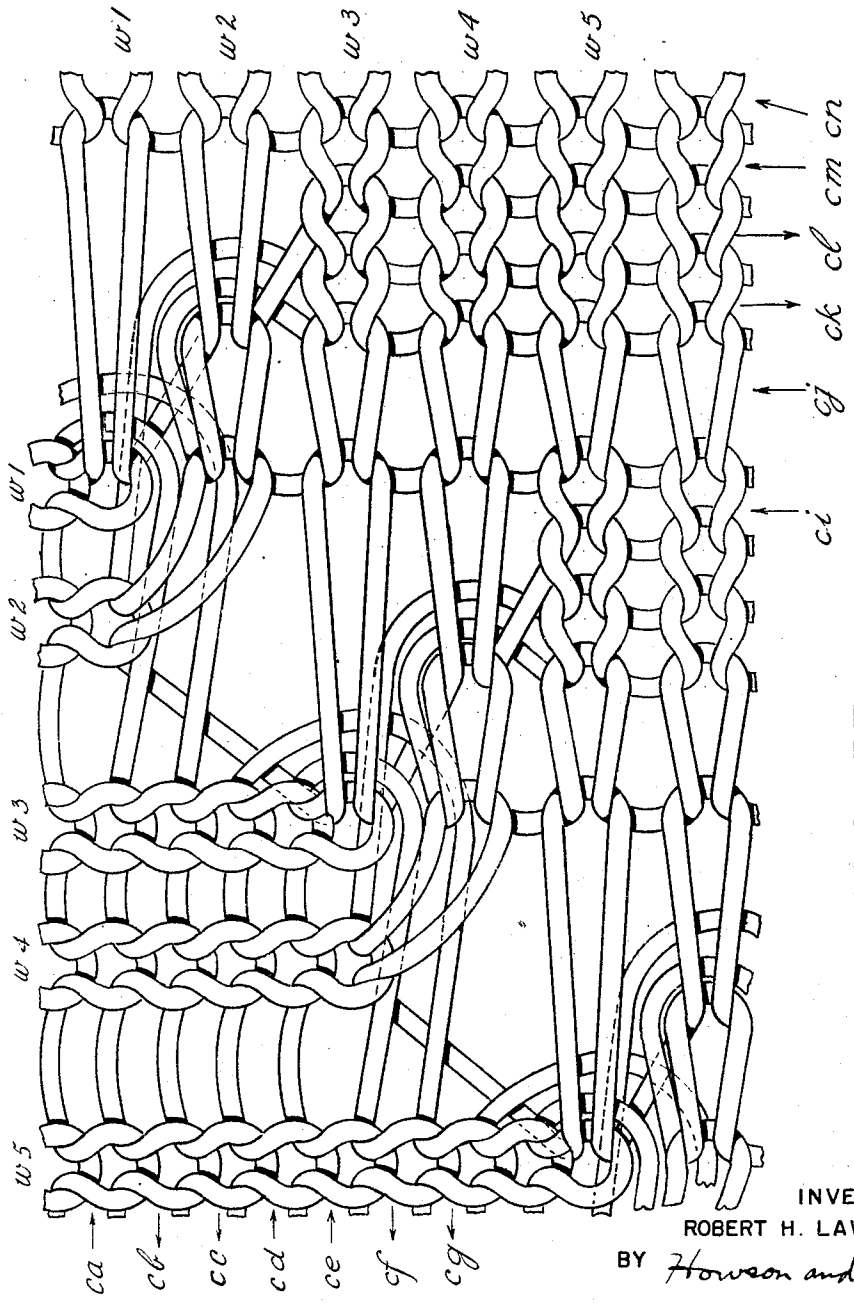

Fig. 37.

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Patented Apr. 27, 1948

2,440,280

UNITED STATES PATENT OFFICE

2,440,280

KNITTING MACHINE AND METHOD OF KNITTING

Robert H. Lawson, Lakeport, N. H., assignor to Scott & Williams, Incorporated, Laconia, N. H., a corporation of Massachusetts

Application November 13, 1943, Serial No. 510,166

9 Claims. (Cl. 66—48)

1

This invention relates to a method of knitting and to a machine on which the method may be carried into effect. The invention is directed, more specifically, to the knitting of sutures, such as seamless heel and toe sutures, on independent needle, circular hosiery knitting machines, e. g., machines having rotary or stationary needle cylinders, as well as to the knitting of garments such as fashioned underwear.

The primary purpose of the invention is to effect a saving of time in the knitting of stockings and other articles, for example, those having portions knitted by reciprocations of a needle cylinder and more particularly where, during such reciprocations, needles are progressively picked up out of knitting position and then moved back into knitting position to effect sutures such as those present in so-called seamless stockings. The saving of time in the manufacture of the stockings and other articles is effected by feeding a plurality of yarns, each at a separate feeding station, and in such a manner that during reciprocation of the needle cylinder two or more courses are knitted during each rotary movement of the needle cylinder instead of one course as is now the common practice.

In the following description, the knitting of several variations of sutures, such as heel and toe sutures, is described merely by way of illustration, as the versatility of the machine and the adaptability of the methods disclosed permit of such a great number of suture variations that it would not be practicable completely to disclose all of the possible variations. Accordingly, the following description will be limited to a few selected forms of sutures, in each of which a great many suture variations are possible, as by varying the selective control and construction of the picking instrumentalities.

In the drawings:

Fig. 1 is a view in side elevation of a knitting machine constructed in accordance with the present invention;

Fig. 2 is a view in elevation taken from the other side of the machine of Fig. 1;

Fig. 3 is a perspective view showing the bed plate of the machine and parts carried thereby;

Fig. 4 is a view of the pattern chain that determines the operation of the machine;

Fig. 5 is a developed view of drum cams that control the movements of various connections which effect the knitting of a stocking;

Fig. 6 is a view complemental to Fig. 5 showing the cams for effecting selective movements of the narrowing picks;

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Fig. 7 is a view similar to Fig. 6 showing the cams for controlling the movements of the widening pick and switch cams;

Fig. 8 is a view showing the cam for effecting the knitting of a loose course;

Fig. 9 is a fragmentary view showing part of the pattern chain and the means for advancing the main pattern drum as determined by the pattern chain;

Fig. 10 is a fragmentary view of the latch ring showing the yarn feeding portions thereof;

Fig. 11 is a view from the inside of the needle cylinder showing a modification of the latch ring of Fig. 10 and the knitting of two yarns, the needles being shown traveling in a counter-clockwise direction;

Fig. 12 is a view similar to Fig. 11 but showing the needles moving in the opposite direction;

Fig. 13 is a top plan view of the sinker cap, the sinker cams and sinker raceway being shown in dotted lines;

Fig. 14 is a perspective view showing the under side of the sinker cap of Fig. 13;

Fig. 15 is a perspective, fragmentary view, complemental to Fig. 14, showing the needle cams and their relation to the sinker cams in the sinker cap of Fig. 14;

Fig. 16 is a view showing the leading heel or toe needle engaging a narrowing pick preparatory to the pick elevating the said needle, and the next following needle, to an inactive position;

Fig. 17 is a view similar to Fig. 16 but showing the pick at the other side of the machine, and the needles moving in a direction opposite to their movement in Fig. 16;

Fig. 18 is a view similar to Fig. 16 but showing the pick positioned for the picking of a single needle only;

Fig. 19 is a view similar to Fig. 18, showing in dotted lines the path of movement of the pick and leading needle when the latter is moved to an inactive position;

Fig. 20 is a view similar to Fig. 19, but showing the elevation of two leading heel and toe needles;

Fig. 21 is a view showing the action of the widening pick in returning needles from their inactive position to the knitting level;

Fig. 22 is a view in plan showing a portion of the bedplate, as well as the widening pick and switch cams carried by the bedplate;

Fig. 23 is a fragmentary perspective view showing the widening pick and switch cam brackets;

Fig. 24 is a fragmentary view in elevation showing the switch cams of Figs. 22 and 23.

Fig. 25 is a corresponding view of the widening pick;

Fig. 26 is a view in plan showing the bedplate and cams and narrowing picks carried thereby;

Fig. 27 is a view similar to Fig. 26 but in perspective;

Fig. 28 is an enlarged view showing a narrowing pick of Figs. 26 and 27 and means for moving the pick to elevate one or two needles at a time;

Fig. 29 is an enlarged view of a detail shown in Fig. 26;

Fig. 30 is a partial plan view of a stocking diagrammatically illustrating the methods of knitting;

Fig. 31 is a diagrammatic view indicating the sequence of courses knitted with two yarns;

Fig. 32 is a view similar to Fig. 31, but indicating the knitting of three yarns;

Fig. 33 is a view showing diagrammatically one method of knitting the heel or toe of the stocking of Fig. 30;

Fig. 34 is a detail view illustrating the relation of the yarn to the needles upon the elevation of two needles to an inactive position by a pick;

Fig. 35 is a view similar to Fig. 33 but illustrating a modified method;

Fig. 36 is a view similar to Figs. 33 and 35 but illustrating another method; and

Fig. 37 is a diagrammatic view drawn to a larger scale and showing the arrangement of the loops along the suture line of a fragment of a heel or toe in accordance with this invention.

In the drawings, a machine designed to carry out the principles of the present invention and thus effect the knitting of the stocking illustrated in Figs. 30, 31 and 32, is indicated generally by the numeral 1. The machine shown includes a bedplate 2 to which is attached a cam ring 3 which includes curved cams 4, Fig. 27, connected to an upwardly extending flange 5, carried by the bedplate 2. The upper edges of the said curved cams 4 and latch clearing cams 14, 15 form the lower part of a raceway for the needle butts 6, 6' of needles N in a needle cylinder 260, see Fig. 3. The upper part of the raceway is defined by the center stitch cam 9, guard or wing cams 10, 11 and stitch cams 12, 13. The center stitch cam 9 is fastened to a block 16, the block 16 and stitch cams 12, 13 being affixed to an arcuate plate 17 which is fastened to the bedplate 2 by screws. To posts 18, 19, Fig. 3, carried by bedplate 2, are fixedly secured the guard or wing cams 10 and 11 respectively. The cams mentioned, with the exception of the cams 14 and 15, are fixed. The cams 14 and 15 are pivoted, Figs. 26, 27, on the posts 18, 19, respectively, and are pivotally connected to the ends of an adjustable two-part link 20 by means of pins 21 and 22 respectively. On the pins 21 and 22 are mounted levers 23 and 24 respectively, cotter pins retaining said levers and link 20 in place on the said pins 21 and 22. The outer ends of the levers 23, 24 are reduced and the reduced ends are seated in holes in the upper ends of flat springs 25 and 26 connected to and upstanding from the bedplate 2. Passing through the reduced ends of the levers 23 and 24 are pins 27 and 28 which seat against the respective springs 25 and 26, so that the springs by pressing against the pins 27, 28, retain levers 23, 24 in the position shown, Figs. 26, 27, or alternately in the position assumed when cam 14 is in operative position. The construction is such that, during reciprocations of the needle cylinder, one cam 14 or 15, as the case may be, moves to the active position shown by the cam 15 in Fig. 27 which

movement, due to the connecting link 20 moves the other cam 14 to the inactive position shown in part by dotted lines, Fig. 26.

To knit the stocking 29, Fig. 30, the needle cylinder 260 rotates within the cam ring 3 during circular knitting of the leg 30 and foot 31 of the stocking and reciprocates during the knitting of the heel 32 and toe 33 of the stocking. The narrowed and widened portions of the heel 32 are joined in a suture 34, the corresponding toe suture being indicated at 35. Preceding the knitting of the toe, the usual ring toe may be knitted.

The cam ring 3 comprises fixed and movable cams that act upon the butts of the needles N to move the needles to and from the positions in which the needles engage and knit the yarns Y and Y' to effect the knitting of the stocking 29. Cooperating with the needles are sinkers 36, Fig. 3, which are mounted in slots in a sinker head 37 as usual, the sinkers being provided with butts 38, Fig. 13, movable in the cam raceway 39 of the sinker cap 40. During circular knitting of the leg and foot of the stocking, the sinker cap 40 is held against rotation by a stop lug 41 engaging the side face of a post 42 attached to the bedplate 2 by screws and upstanding therefrom. During reciprocatory knitting the sinker cap 40 oscillates slightly (limited by stop lugs 41, 43, engaging opposite sides of post 42) upon reciprocation of the needle cylinder, to maintain the cam raceway 39 of the sinker cap 40 in proper timed relation with the needle actuating cams as the relation of the yarns to the needles changes upon each reversal of the movement of the needle cylinder. The sinker head 37, within which the sinkers are mounted, is attached to and forms part of the needle cylinder 260, rotating and reciprocating therewith. The sinker cap 40 is secured to the sinker head 37 by angle plate 44 in the usual manner.

To effect the knitting of the heel and toe of the stocking shown in Fig. 30, narrowing or up picks 45, 46, Figs. 3, 16–20, 26 and 27, are employed. These picks are controlled to effect the prescribed picking sequences, as will be hereinafter more specifically described. Cooperating with the narrowing or up picks during the knitting of the second or widened half or portion of the heel and toe of the stocking is a widening or down pick 47, Figs. 21–25, and acting in conjunction with the picks are switch cams 48, 49, Figs. 22, 23, 24 mounted in a bracket 49' carried by bedplate 2. The operation of cams 48, 49 and their cooperation with the picks will be hereinafter more fully described.

Carried by and upstanding from the bedplate 2 are posts 50, 51, Figs. 3, 26, 27 and 28 to which respectively are connected the narrowing or up picks 45 and 46 which are pivotally mounted in swiveled housings 52 and 53 respectively, the construction being such that when a needle butt engages and causes one of the picks to ascend and swing to an up position and then to an inoperative position, the other pick is moved to an operative position. The pivotal mounting of the picks in their respective housing permits the picks to move upwardly and thereby raise the needles as indicated by the full and dotted line positions of the pick 46, Fig. 19. The raising of the picks, incidental to their horizontal swivel movements, is effected by identical cam plates 54, 55 having pick raising cams 56, 57 and stops 58, 59 to prevent overthrow of the picks. Springs 60 retain the picks in contact with their respective cam plates. Two-part adjustable links 61 are pivotally

connected together and to a plate 62 by a screw, said plate 62 oscillating on a post 63 (upstanding from bedplate 2) as each pick moves to and from a picking position. At their remote ends said links are pivotally connected to the respective housings 52, 53 by pins 64, 65, slots in the ends of the links permitting play and cotter pins retaining the links in place.

The picks 45 and 46, Figs. 16–20, 26 and 27, are shown with two steps. When a pick is positioned as shown in Fig. 19, a single butt only is engaged by the lower step of the pick, whereas when the pick is in the position shown in Fig. 20 a butt is engaged by each step of the pick, and their needles raised to an inactive position. To effect the selective positioning of the picks to pick one or two needles, as the case may be, duplicate cams 66, 67, Figs. 3, 26 and 28, are provided, said cams being pivoted to the plate 17. Each cam 66, 67 is rounded, as shown at 68, Fig. 20, and has a flat upper surface 69 against which the companion pick rests when positioned to pick single needles. By swinging either cam 66, 67 on its pivot to engage the pick, the respective picks are elevated to the single-needle picking position of Fig. 19 from the two needle picking position of Fig. 20.

Pivotally connected to the respective cams 66 and 67 are arcuate links 70, 71, the other ends of which links are pivotally connected to a disc 72, rotatively supported on the upstanding post 63. A link 73 is pivotally connected to the disc 72 to turn the same and, consequently, simultaneously swing the cams 66 and 67 so that their companion picks 45, 46 shall be moved either to the position shown in Fig. 19 or to the position shown in Fig. 20.

The switch cam 49 comes into play preparatory to heel and toe knitting to raise the long butt or instep needles to an inactive position and the switch cam 48 restores the idle needles to knitting position at the termination of the knitting of the heels and toes of stockings. The widening or downpick 47 is moved to picking position during the knitting of the second or widened portions of the heels and toes of stockings and thereafter is moved to a non-picking position.

To effect the necessary movements of the pick 47 and cams 48, 49, there is provided a movable rod 74 having a hub 75 adjustably fastened thereto, the hub having arms 76, 77. The arm 77 when raised engages a lever arm 78, rocking the same and causing a pin 79 and attached cam 49 to be advanced to elevate the long butt needles. At the same time the arm 76 compresses a coiled spring 80 surrounding a pin 81 which carries a button 82 at the upper end thereof, the pin 81 being movable through the arm 76. Compression of the spring 80 causes the button 82 to rock an arm 83 and move the widening pick 47 to a non-picking position. When the arm 76 moves down, through the action of spring 84, Fig. 1, the pressure exerted by the spring 80 is released, as a consequence of which the arm 83 drops and the widening pick is moved to the picking position of Fig. 25, a spring 88 effecting the movement of the pick. The arm 77 moves down with the arm 76 and continued downward movement of the arm 77, following release of the widening pick 47, rocks lever 85, thereby rocking the intergeared lever 86, which engages pin 87, advancing the switch cam 48, against the retractile force of spring 48', to move the previously idled needles to the knitting level.

The switch cams and widening pick are similar

in construction and operation to the corresponding switch cams and widening picks disclosed in the Page et al. Patent 1,841,205 of January 12, 1932.

For the knitting of the stocking of Figs. 30, 31 and 32, yarns Y and Y' are fed to the needles, Figs. 10, 11 and 12, the yarn Y passing through a guide 89 pivotally mounted in an extension 90, and extending into a throat 91a of a latch ring 91 which has the customary latch guard 92. The yarn Y' may be fed through a slot 93 in the latch ring 91, as shown in Figs. 1, 2 and 10, or through a guide 94 in second throat 91b in the latch ring, as indicated in Figs. 11 and 12.

The two yarns Y, Y' are separate-course yarns, two courses being knitted during each rotation or rotary movement of the needle cylinder, as illustrated more or less diagrammatically in Figs. 30 and 31. Fig. 11 illustrates the knitting of two courses while the needles are traveling in a counterclockwise direction for circular knitting and one movement of reciprocatory knitting for knitting the heel and toe. As shown in Fig. 11, the butts of the needles, in moving from right to left, are engaged and their needles elevated by cam 13, then depressed by cam 11 and further depressed by the stitch cam 9, yarn being engaged in the hooks of the needles and drawn through previous course stitches. Thereafter the needles shown are elevated by the cam 95, constituting part of cam ring 3, are further elevated by movable cam 14, and are again depressed by cams 10 and 12, the needles engaging yarn Y' in their hooks and drawing bights of the yarn through the stitches drawn by the needles of the yarn Y as they were depressed by the cams 11 and 9. Upon the needle cylinder reversing its direction of movement, the short butt needles move from the left to the right, Fig. 12, the said butts riding up the cam 12 and being depressed by cams 10 and 9 with the needles drawing bights of yarn Y' through previous course loops. The butts then ride up cam 96 of the cam ring 3, are further elevated by movable cam 15 and are then depressed by cams 11 and 13, drawing bights of yarn Y through the stitches drawn of the yarn Y' as the needles were depressed by the cams 10 and 9. Thus during reciprocations of the needle cylinder for example, as during the knitting of heels and toes, two courses are knitted for each rotary movement of the needle cylinder in either direction, i. e. as illustrated in Figs. 11 and 12. During continuous circular movement of the needle cylinder in the direction illustrated in Fig. 11, the yarns Y and Y' are alternately knitted by each needle, each yarn alone appearing in alternate courses, whereas during reciprocatory knitting the yarn Y is first knitted as the needles move in the direction of Fig. 11, followed by the knitting of the yarn Y'. Upon the needle cylinder reversing its direction of movement, the yarn Y' is again knitted, Fig. 12, followed by the knitting of yarn Y. In other words, during the knitting of heels and toes there are groups of two consecutive courses alternately knitted of the yarns Y and Y' each yarn alone appearing in its courses.

To cause the needle cylinder 260 to rotate during the knitting of the leg and foot of the stocking 29 and to reciprocate during the knitting of the heel and toe, the machine is equipped with the usual driving clutch and clutch shifting mechanism for driving the needle cylinder and for changing the movements thereof from rotary to reciprocating and back to rotary, as shown in the

patent to Scott 1,152,850, Sept. 7, 1915. Such mechanism includes bevel gear A, high speed gear B and quadrant C shown at 31, 65 and 75 respectively in the said patent to Scott.

The necessary cam and pick movements to effect the knitting of a stocking such as 29 are controlled by a pattern drum 97, Figs. 1–9 inclusive, which is periodically advanced in the direction of the arrow, Fig. 1, cams on the drum effecting and timing the necessary movements of the switch cams 48, 49 and narrowing pick cams 66, 67, as well as the loose course movement of the needle cylinder 260, all as will now be described.

Upon advancing movements being imparted to the drum 97, cams 98 and 99 rock lever 100 by engaging the toe thereof. The lever 100 is pivotally mounted on a shaft 101 and has pivoted thereto the rod 74 which, through connections hereinbefore described, effects movements of the switch cams 48 and 49 and widening pick 47.

Cams 102 and 103 on the drum 97 engage a thrust bar 104 which thrust bar is pivoted at 105 to one arm of a bell crank lever 106. The lever 106 is pivotally mounted on stub shaft 107 projecting laterally from the bracket 108 to which the latch ring 91 is pivoted. Engagement of the thrust bar 104 by the cams 102 and 103 effects a rocking of the lever 106 and the operation of the wire rod 73 pivotally connected to the other arm of the lever 106, the rod 73 passing loosely through a swivel screw 110 projecting from said lever 106. Collars 111, 112 and 113, Fig. 3, adjustably fastened to the rod 73 on each side of the swivel screw 110, retain the rod in position while permitting some play of the rod in the swivel screw. The other end of the rod 73 is upturned and connected to the disc 72, Fig. 28, the connection effecting turning movements of the disc 72 upon the rocking of the bell crank lever 106 by the cams 102 and 103. The turning of the disc 72 acts upon the arcuate links 70, 71 to position the picks 45, 46 for single or double needle picking. A collar 114 is connected to post 63 by screw 115 and provides a seat for the disc 72. A spring 116, Fig. 1, is connected at 117 to thrust bar 104 and to a thrust bar spacer 118 which is attached to a rod 119 carried by a convenient part of the machine frame. The spring 116 consequently retains the thrust bar 104 in engagement with the drum 97 or cams thereon, permitting the picks 45, 46, to drop for double picking.

A cam 120 on drum 97 rocks a lever 121, pivoted on rod 119, the lever having laterally projecting lug 122 through which passes an adjustable screw 123 positioned to engage an arm 124 connected to and projecting from a fabric tube 125 to which the needle cylinder 260 is connected. Consequently the rocking of the lever 121 effects a slight elevation of the needle cylinder to cause the needles to draw longer stitches of the yarns Y and Y' for the usual loose courses at the toe of the stocking thus facilitating looping of the toe.

The advancing movements of the drum 97 as well as the directional changes in the rotation of the needle cylinder, yarn changes, etc., are all primarily controlled by a pattern chain 126 which chain is mounted on a sprocket 127 loosely carried by a shaft 128.

The pattern chain 126 is intermittently advanced, as described in connection with the chain 438 in the patent to Scott 1,148,055, July 27, 1915. The movements imparted to the chain 126 bring lugs carried thereby to a position to cause a pawl 129, Fig. 9, to advance a ratchet wheel 130, as disclosed in the Scott patent.

The prescribed and timed advancing movements are imparted to pattern drum 97 as governed by the pattern chain 126 which is provided with the usual plain links 131, each link representing the knitting of twelve courses. With links 131, the chain 126 is provided with a number of links having lugs which rock a pawl holder 132, pivoted on a shaft 133, Fig. 2, causing the toe 134 thereof to drop, thereby permitting the pawl 129 to engage the teeth of the ratchet wheel 130. The height of the lugs on the chain 126 determines the extent of drop of the pawl 129, as a consequence of which the ratchet wheel 130 may be advanced circumferentially through arcs measured by a short tooth, an intermediate tooth, or a long tooth. The ratchet wheel 130 is connected to rotate a shaft 128, to which is also affixed a gear 135, Fig. 1, meshing with an intermediate gear 136 loosely mounted on a shaft 101, the gear 136 in turn meshing with a gear 137 affixed to the shaft 138 upon which the pattern drum 97 is mounted. Thus, as controlled by the chain 126, advancing movements imparted to the ratchet 130 by the pawl 129 advance the drum 97 through a corresponding arc. Although primarily controlled from chain 126, the movements imparted to the drum 97 are dependent upon the arrangement of long, intermediate and short teeth of the ratchet wheel 130 and the lugs on the pattern chain 126. In other words, if a different arrangement of long, short and intermediate teeth were provided on the ratchet wheel, the complementary lugs on the pattern chain would be differently arranged.

It sometimes happens, as will be presently described, that the pawl 129, when dropped by a lug on the pattern chain 126, will not engage the next tooth on the ratchet 130. To effect the movement of the shaft 128 an auxiliary pawl 139, Fig. 2, is availed of, which advances the shaft 128, and, as a consequence thereof, the ratchet 130 to such a position that upon the next reciprocation of the constantly reciprocating pawl 129 a further advance of the ratchet 130, and consequently of the drum 97, is effected.

The pawl 139 is pivotally connected to a bell crank lever 140 which is pivotally mounted on the shaft 138, swinging movements of the lever 140 and consequently of the pawl 139, being limited by a pin 141 on the shaft 138 engaging a slotted collar 142 carried by the lever 140. The other arm of the lever 140 carries an adjustable follower 143 engaged by cams 144 or 145 every other course of knitting. Engagement of the follower 143 by cams 144, 145 rocks the lever 140, moving the pawl 139 and advancing an auxiliary rack wheel 146 whenever teeth 147, 148 or 149 are in a position to be engaged by pawl 139. The pawl 139 is maintained in position to engage said teeth, by a spring 140'.

The operation of the various parts to effect the knitting of the stocking 29 shown in Fig. 30 will now be described. The stocking shown in Fig. 30 is knitted as string work, the top of a stocking immediately following the loopers rounds of the preceding stocking. To complete the stocking elastic yarn may be incorporated in the selvage course, e. g. as disclosed in the patent to Getaz 2,054,217, or the top (not shown) may be attached to the top portion of the leg, as by sewing. Alternatively, the top of the stocking may be finished by a turned welt or the needles may be levelled off in the usual manner and rib tops transferred to the machine prior to the knitting of the legs of the stockings.

To effect the knitting of the stocking 29, the

chain 126, Fig. 4, is provided with a lug 150 which fills one chain link and a lug 151, having a low step 151', on the next following chain link. The high portion of the lug 151 is of the same height as the lug 150. The high portions of the lug, such as 151, effect a full drop of the pawl 129 so that, upon the next reciprocation thereof, the pawl will have a throw sufficiently long to advance the rack wheel 130 through an arc measured by four short teeth, such as indicated by the numeral 152, Fig. 9, or one long tooth, such as indicated by the numeral 153. Although the pawl 129 has the capacity for advancing the ratchet 130, as just stated, the actual advance of the ratchet 130 depends upon the location of the various teeth on the ratchet; in other words, the pawl 129 in a reciprocation may move sufficiently to advance the ratchet 130 through an arc measured by four short teeth, but, if the teeth on the ratchet 130 are not appropriately positioned with respect to the pawl, the ratchet will not be advanced through the mentioned arc. As there are three kicks or reciprocations of the pawl 129 for each chain link, the long lug 150 accounts for three long reciprocations of the pawl 129 and the high portion of the following lug 151 accounts for another long reciprocation of the pawl. The low step 151' effects a partial dropping of the pawl 129 and to an extent sufficient to permit the said pawl to advance the ratchet 130 through an arc measured by two short teeth, the advance of the ratchet depending upon the presence of an appropriately positioned tooth on the ratchet 130.

Although, as shown in Fig. 4, the lugs 150 and 151 are attached to the first two links of the chain 126, the resulting movements of the ratchet 130 are merely for the purpose of advancing the drum 97 to such a position that a subsequent movement thereof will affect the knitting operation; in other words, the lugs 150 and 151 could be attached to any others of the links in advance of the link to which the lug 154 is attached.

The stepped lug 154 comes into play to effect the beginning of the knitting of the heel 32 of the stocking, the chain 126 having been advanced in the usual manner during the knitting of the leg. The low step 154' of the lug drops the pawl 129 to advance the ratchet 130 through the distance measured by two of the short teeth, whereas the higher portion of the lug 154 causes the pawl 129 to advance the ratchet 130 through the longest rack, i. e. measured by four short teeth. While the pawl holder 132 remains on the low step 154' of lug 154 the pawl 129 cannot again advance the rack wheel 130 as a tooth is not appropriately positioned thereon to permit the said pawl to advance said rack wheel 130, but the advance of the rack wheel controlled by the low step 154' of the lug 154 advances the auxiliary rack wheel 146 to a position in which the tooth 147 is engaged by the pawl 139 on the next operation thereof to advance the rack wheel 146 and rack wheel 130. This advance of rack wheel 130 is virtually a continuation of the previous rack or advance of rack wheel 130. Such advance of rack wheel 130 and the dropping of the toe 134 of pawl holder 132 as it is lowered by the high step of lug 154, permits pawl 129 to advance the ratchet 130. Advance of the rack wheel 130 turns shaft 128 and, through the gearing connections hereinbefore described, advances the drum 97 in the direction of the arrow, Fig. 1, to move the lever 100 from position 155, Fig. 7, to a position on top of the cam 98. The consequent rocking of the lever 100 causes the cam 49 to be advanced to

raise the long butt needles preparatory to knitting of the heel 32, the widening pick being out of action. The narrowing picks 45, 46 are at this time positioned to elevate two needles at the leading end of the active short butt needles at each back and each forth movement of the needle cylinder until the narrowing is completed, at which time the pattern chain 126 has been advanced to such a position that another lug 156 on the said chain acts upon the pawl holder 132 to permit the pawl 129 to drop to a position to advance the ratchet 130, which movement advances the drum 97, through the connections hereinbefore described. The advance of the drum 97 causes the cam 103 to act upon the toe of the thrust rod 104, thereby rocking the bell crank lever 106, and through the link 73 to rock the cams 66, 67 to move the picks 45, 46 from the dotted to the full line position of Fig. 28, so that the said picks shall pick up single needles at each back and each forth movement of the needle cylinder throughout the second or widening portion of the heel. The mentioned picking, while descriptive of one method, may be varied, as will be hereinafter more fully set forth.

The next operation of the pawl 129 (the pawl remaining down because of lug 156) engages another tooth of the rack wheel 130, again advancing the same. This advance of the rack wheel does not advance the drum 97 far enough to affect the knitting. The auxiliary rack pawl 139, however, engages tooth 148 advancing rack wheel 146, and consequently main rack wheel 130 and drum 97 causing the toe of the lever 100 to drop on to the lower step 158 of the cam 98. This movement of the lever 100 permits the widening pick 47 to move up to its normal picking position of Fig. 25, where it picks down, or moves to knitting position, three of the previously elevated short butt needles, such picking occurring at each back and each forth movement of the needle cylinder throughout the knitting of the second half or portion of the heel 32.

Continued movements of the pattern chain 126 bring a stepped lug 159 to such a position as to permit the pawl 129 to drop into engagement with a tooth of the main rack wheel 130 and advance the same. The low step 159' of the lug does not cause the pawl 129 to advance the rack wheel 130 merely easing the climb of the toe of pawl holder 132 onto the high step of the lug 159 which drops the pawl 129 to a position to engage a long tooth of the rack wheel 130 to advance the said rack wheel, consequently advancing the drum 97 to such a position that the toe of the lever 100 drops onto the surface of the drum at 160, and, through the connections described, causes the switch cam 48 to advance and restore the long butt needles to a knitting position. Circular knitting is then resumed by the needle cylinder continuously rotating in the same direction while the foot 31 of the stocking is being knitted.

Further advance of the pattern chain 126 during the knitting of the foot brings a lug 161 to a position to permit the pawl 129 again to advance the main rack wheel 130. The lower step 161' of the lug 161 does not drop the pawl 129 to a position to advance the rack wheel, the advance being effected by the high portion of the lug 161 dropping the pawl 129 to a position to advance the rack wheel and consequently drum 97. The advance of the drum 97 causes the toe of the lever 100 to rise up on the cam 99, resting thereon at 162, and causing the cam 49 to be advanced adjacent to the short butt needles to elevate the long

butt needles to an inactive position where they remain during the knitting of the toe 33 of the stocking, the picks 45, 46 picking up two needles at each back and each forth movement of the needle cylinder. After the toe 33 has been narrowed sufficiently, a portion 163 of another lug of the chain 126 drops the pawl 129 to advance the rack wheel 130 and thereby the drum 97. This advance of the drum 97 does not affect the knitting however, and the pawl holder 132 remains resting on the portion 164 of the lug. The next operation of the pawl 129 again effects an advance of the drum 97 thereby causing the toe of the thrust rod 104 to ride up on the cam 102 at 165, rocking the bell crank lever 106, and moving the picks 45, 46 to the full-line, single needle picking position of Fig. 28. As the pawl holder rests on portion 166 of the lug, the next operation of the pawl 129 again advances the rack wheel 130 and the drum 97. While the pawl 129 is positioned for a long movement of the rack wheel 130, the position of the teeth on the rack wheel is such that a short advance only of the rack wheel and drum 97 is effected. The auxiliary pawl 139 now comes into operation by engaging tooth 149 and effects a further advance of the drum 97, which is, in effect, a continuation of the previous advance effected by the pawl 129. The secondary advance of the drum 97 permits the widening pick 47 to move to an operative position as the toe of the lever 100 drops onto a step 167 of the cam 99. Thereafter throughout the knitting of the widened portion of the toe 33, single needles are elevated by the narrowing picks 45, 46 on each back and each forth movement of the needle cylinder while three needles are moved to knitting position by the widening pick 47 at each back and each forth movement of the needle cylinder. After the toe 33 has been sufficiently widened, a lug 168 drops the pawl 129 to advance the rack wheel 130 and drum 97, the toe of the lever 100 dropping onto the surface of the drum 97 at 169, causing the cam 48 to move a position to restore the high butt needles and any elevated short butt needles to the normal knitting level, whereupon circular knitting by continuous rotary movement of the needle cylinder is resumed to effect the knitting of so-called loopers rounds.

During round and round knitting the needle cylinder is operated counter-clockwise, as shown in Fig. 11, and at this time the sinkers are operated so that at the casting off points 300 and 302 (Fig. 14) the sinkers are fully inserted a short distance after the knitting point, the cast off point 300 being between points 310 and 311 (Fig. 11) and point 302 being between points 312 and 313 at a point where the head of the needle is approximately level with the edge of the sinker over which the yarn has been drawn in the usual way.

During reciprocatory knitting when the needle cylinder is moving clockwise the casting off points are located so that at cast off point 301 the sinkers are fully inserted between the points 314 and 315 (Fig. 12) while at cast off point 303 the sinkers are fully inserted between points 316 and 317 at a point where the needles have been raised so that their heads are level with the edge of the sinker over which the yarn has been drawn in the usual way.

As shown in Figs. 13 and 14, the sinker withdrawing cams 320 and 321, positioned between the cast off points 300—301 and 302—303, respectively, are shaped so there is formed a narrow raceway for the butts of the sinkers between the cast off cams 330, 331 and 332 and the withdrawing cams 320 and 321 so that the sinkers cannot be moved in ahead of time especially when a spring band is used to control them as is usual on a Scott and Williams machine. Where the sinkers are allowed to be moved in ahead of time, enlarged stitches are caused due to the yarn being drawn over the nose of the sinkers.

The cams in the sinker cap are so proportioned that when the needle cylinder is rotating counter-clockwise and the control bumper 41 with its adjusting screw is against the post 42, as shown in Fig. 1, the sinkers are withdrawn by the cams 320 and 321 after the needles have passed over the tops of cams 14 and 13, respectively. When the needle cylinder is rotating in a clockwise direction, the withdrawing cams 321 and 320 withdraw the sinkers after the needles have passed over the tops of cams 12 and 15, respectively, the bumper 43, with its adjusting screw then being in contact with the post 42. Earlier withdrawal of the sinkers would allow the stitches to follow up with the needles so the latches would not be clear of the stitches.

While the numbers of courses in the various parts of a stocking may be varied, depending upon the desired lengths of leg and foot as well as upon the desired heel and toe construction; in stockings such as the one the knitting of which has just been described, the leg 30 may comprise one hundred and forty courses, the heel 32 one hundred courses, the foot 31 one hundred and four courses, and the toe 33 one hundred courses.

In the foregoing description of operation, the necessary and timed rack, drum and cam movements have been set forth in detail for illustrative purposes only and to describe the knitting of one form of stocking. The knitting of other forms of stockings, e. g. those alternatively described in the specification, will affect the location of the appropriate lugs on the chain 126 and, in some instances, the positioning and lengths of the cams on drum 97.

In the showing of the stocking in Fig. 30, the relatively heavy lines 170 indicate courses knitted of the thread Y' and the relatively light lines 171 indicate courses knitted of the yarn Y. The stocking comprises a top (not shown), a leg 30, a heel pocket 32, a foot 31 and a toe 33.

The top may be knitted by any one of the well known methods, the method employed being immaterial insofar as the present invention is concerned, which is primarily directed to the knitting of the leg and foot portions of the stocking of two threads, each thread appearing only in alternate courses and knitting the heel and toe portions of the stocking with the same two threads, or substitute threads, the two threads alternately appearing without the other thread in groups of two adjacent courses throughout the heel and toe portions of the stocking.

While two threads or yarns Y and Y' have been shown, the invention in its broader aspects is not restricted to the use of two threads, but embraces the use of a plurality of threads, each of such plurality of threads alternating with each of the other threads in the leg and foot portions of the stocking, and each of two of such threads appearing only in at least two consecutive courses of the heel and toe portions of the stocking.

In Fig. 31 there is diagrammatically illustrated a few circular leg or foot courses of the stocking of Fig. 30, as viewed from the inside thereof, and following courses of the heel or toe. The yarn Y is shown as alone appearing in circular course

172, the yarn Y' alone appearing in the next following circular course 173. The courses 174 and 175 are knitted respectively of the yarns Y and Y' alone, such courses constituting the last circular courses knitted by the needles while traveling in a counterclockwise direction (looking from above) preparatory to the first reverse or clockwise movement of the needles to knit the heel 32 or toe 33 as the case may be. The knitting of the last circular courses 174 and 175 proceeds in the direction of the arrow (Fig. 31), that is, from the left to the right of the said figure, the knitting of the first reciprocatory (heel or toe) courses 176 and 177 from right to left of Fig. 31, the following groups of two courses being alternately knitted in opposite directions, as indicated in Fig. 31.

As the needles first move in the direction reverse to the direction of circular knitting, the yarn Y', which knitted the last circular course 175, knits the first reverse course 176, the yarn Y knitting the following course 177 in the same direction of knitting. The needles again reverse their direction of movement to knit the following courses 178 and 179, the yarn Y knitting the course 178 and the yarn Y' the course 179. As indicated in Fig. 31, the yarn, either Y or Y' as the case may be, is the last yarn to knit during one direction of movement of the needles and is the first yarn to knit upon the needles reversing their direction of movement, so that throughout the heel or toe portions of the stockings the yarns Y and Y' each alone appears in consecutive groups of two courses. Also, as indicated in Fig. 31, upon each reversal of direction of the movement of the needles, the yarn Y' floats, as at 180, 181, across two courses knitted of the yarn Y, as shown at the left of Fig. 31, and the yarn Y likewise floats across two courses knitted of the yarn Y', as indicated at 182 and 183 at the right of Fig. 31.

While indicated as floats, the yarn Y at the left of Fig. 31 and the yarn Y' at the right of Fig. 31 do not float at the places indicated in the sense of floating across intervening courses, the yarns Y and Y' merely pass from one wale in one course, e. g. course 175, to an adjacent wale in a following course such as 176.

In Fig. 31 at each indicated reversal of the courses, the lines connecting, for example, the courses 177, 178 and 176 and 179 are inclined to show the courses as progressively shortening and then as progressively widening. The progressive shortening indicates the narrowing of the heel or toe pocket by the picks 45 or 46, as the case may be, elevating two needles for each movement of the needles in either direction. The progressive narrowing and widening illustrated diagrammatically in Fig. 31 is, by way of example only, shown extending through a few illustrative courses only, and is based on one of the numerous picking sequences hereinafter to be described, the particular narrowing sequence mentioned being hereinafter described in connection with Figs. 33, 35 and 36.

In Fig. 32 there is disclosed diagrammatically, as in Fig. 31, a modified form of narrowed and widened pocket such as a heel or toe of a stocking which is similar to Fig. 31 but comprising three threads Y, Y' and Y^2.

During the knitting of the circular part of the leg and foot of a stocking, the yarns Y, Y' and Y^2 are knit in rotation, each yarn alone appearing in single courses, as indicated by the courses 184, 185 and 186, knitting proceeding in the direction

of the arrow. The last circular courses 187, 188 and 189, preceding the knitting of the heel or toe of a stocking, are knitted of the respective yarns Y, Y' and Y^2, the said yarns alone appearing in their courses, and during the knitting of which the needle cylinder likewise rotates in the direction of the arrow. To narrow the fabric, preferably, three needles are moved to the idle, instep level during each back and each forth movement of the needles. At the termination of rotary movement of the needles during which the courses 187, 188 and 189 were knit, the needles reverse their direction of rotation and a narrowing pick moves three needles to the idle or inactive level, as indicated at the right of Fig. 32. During this first reverse movement of the needles, the yarns Y^2, Y' and Y knit courses 190, 191 and 192 in that order, the knitting of which proceeds from right to left of Fig. 32. As the needles again reverse their direction of movement to move in the direction of circular knitting, the three leading needles are moved to the idle or inactive level by another narrowing pick. During this movement of the needles, courses 193, 194 and 195 are knitted of the yarns Y, Y' and Y^2 in that order, the knitting proceeding from left to right.

The following groups of two courses, Fig. 31, or three courses, Fig. 32, are alternately knitted in opposite directions, as indicated in Figs. 31 and 32. The last few groups of courses are shown as extending beyond the preceding courses, to indicate the widening of the heel or toe, as the case may be, during which widening needles previously idled during narrowing are restored to the knitting level, interknitting their previously held narrowing course stitches with the stitches of the widened portion of the heel or toe.

While various arrangements of picking sequences may be availed of in the knitting of heel or toe pockets with the three threads Y, Y' and Y^2, one method involves the up-picking of three needles during each back and each forth movement of the needle cylinder while narrowing, as just described, and the down-picking or restoring to action of four needles while the narrowing or up-picks continue to move single needles to the idle or inactive level for each back and each forth movement of the needle cylinder.

As indicated in Fig. 32, the yarn Y', for example, in knitting the courses 188 and 191, floats at 196 across the courses 189, 190 knitted of the yarn Y^2, while the yarn Y in knitting the courses 187 and 192 floats at 197 across four courses, two knitted of the yarn Y' and two knitted of the yarn Y^2, as indicated at the right of Fig. 32. As shown at the left of Fig. 32, the yarn Y', in knitting the courses 191 and 194, floats at 198 across the courses 192, 193, knitted of the yarn Y; and the yarn Y^2, in knitting the courses 190 and 195, floats at 199 across the courses 192, 193 knitted of the yarn Y and also across the courses 191 and 194 knitted of the yarn Y'. The floating of the yarns Y, Y' and Y2 continues throughout each following group of six courses, as shown.

The knitting of the two yarns Y, Y', Fig. 31, will now be described by reference to illustrative examples of methods wherein the picking sequences vary.

As hereinbefore described, to knit the heel 32 or toe 33 of a stocking 29, several methods of picking may be employed, depending upon the desired heel or toe or other construction. Such methods involve the picking up of needles for a

plurality of courses and thereafter restoring such needles again to knit.

In Figs. 33, 35 and 36 are illustrated examples showing different picking sequences applicable to the knitting of either the heels or toes of stockings and to the knitting of other articles, such as berets or certain forms of fashioned underwear, where it is desirable to knit fabrics by progressively idling needles and then restoring them to knitting. As stated, the picking sequences of Figs. 33, 35 and 36 are illustrative only, many other variations being possible by reason of the adaptability of the machine hereinbefore described readily to effect changes in the picking sequences, for example, by varying the action of the narrowing picks 45, 46, as hereinbefore described, or substituting other such picks to effect a different sequence of picking.

The picking sequence occurs as illustrated in Fig. 33 and shown in the following course list where the arrow marked "rotary" indicates the direction of movement of the needles during circular knitting and the other arrows indicate the direction of the movements of the needles during the knitting of heels and toes. The numbers 1 to 20 at the right of the arrow indicate numbered courses, their respective arrows indicating the direction of movement of the needles for any particular course, and the remaining figures indicate the total number of needles at opposite ends of the group of active needles lifted by the picks during rotation of the needle cylinder in each direction. Where the numbers decrease the number of needles lowered by the lowering pick is shown by the decrease in the numbers.

Course list

Rotary→	
← 1	2–
→ 2	2–2
← 3	4–2
→ 4	4–4
← 5	6–4
→ 6	6–6
← 7	8–6
→ 8	8–8
← 9	9–8
→10	9–9
←11	10–9
→12	7–10
←13	8–7
→14	5–8
←15	6–5
→16	3–6
←17	4–3
→18	1–4
←19	2–1
→20	→ 2 Rotary knitting resumed

In Fig. 33, as well as in Figs. 35 and 36, the small squares indicate wales of courses knitted with the thread Y, while the small circles indicate wales of courses knitted on the thread Y'. Furthermore, the squares or circles with X's therein indicate knitted stitches in the indicated courses. The squares or circles without X's therein indicate that the needles knitting those wales did not knit stitches in the indicated courses. The squares or circles having crosses therein indicate the knitting of stitches by needles restored to knitting position during the same course of knitting. The spaces in the variously numbered courses of Figs. 33, 35 and 36, indicate the omission of needles, such omission of needles being also indicated in the circular diagram at the right of and in line with each course designation, the showing in each case being limited to a number of the needles at each end of the short butt series of needles. In this connection, it will be understood that, due to space limitations, the drawings do not show the actual number of needles that are used in knitting the heel and toe portions of the stocking. For example, a needle cylinder may have more than 300 needles, one-half or nearly one-half of which would or might be used to knit the heels and/or toes of stockings. However, the picking sequence is not altered by the addition or subtraction of needles knitting the heels and/or toes of stockings. In the foregoing list illustrating the courses and picking sequence, the total number of heel and toe needles elevated at each side of the needle cylinder reaches a maximum of ten, whereas several times ten needles would be elevated to the idle or inactive level at each side of a needle cylinder in the ordinary commercial hosiery knitting machine, the number of idled needles depending upon the gauge of the machine, as well as the desired heel or toe construction.

Referring specifically to Fig. 33 and to the foregoing course list:

Knitting proceeds in the direction of the arrow (i. e., as though viewed from the inside of a knitted stocking or needle cylinder while knitting proceeds) to complete the knitting of the last circular courses immediately preceding the knitting of courses 1 of the heel 32 or toe 33 of the stocking, the knitting of the stitches proceeding from the left to the right, Fig. 33, the circular Diagram A diagrammatically illustrating the counter-clockwise movement of the needles in the needle cylinder while knitting the last circular courses. The twelve needles shown at the right of Diagram A knit the stitches at the left of said courses, while the needles at the left of the said diagram are the ones that knit the stitches at the right of said courses. Upon the needles reversing their direction of movement, they move in the direction of the arrow in the Diagram B to knit courses 1. During this movement knitting proceeds in a direction from the right to the left of courses 1, the narrowing pick 45 elevating to the inactive level the two end needles at *a* which, as a consequence, do not knit either yarn Y or Y' during the knitting of said courses 1. The next reversal of the movement of the needles (Diagram C) causes courses 2 to be knitted from the left to the right of Fig. 33, the two end needles at *b* being elevated by the pick 46. Courses 3 are then knitted by the needles, again moving in the direction of the arrow of Diagram D, the two end needles at *c* being moved to a non-knitting position by the pick 45. The foregoing picking sequence is continued for a plurality of following reciprocations of the needles, the number of such reciprocations and resulting courses depending upon the number of needles in the knitting machine and the type of heel or toe to the knitted. Because of space limitation in the drawings, Fig. 33 does not show all of the courses indicated in the foregoing course list, courses 4, 5, 6 and 7 of the said list being omitted from Fig. 33. Thus in Fig. 33 courses 8 follow courses 3.

The knitting of courses 8 proceeds from the deft to the right in Fig. 33, the needles moving in the direction indicated by the arrow, Diagram E, the two leading needles at *d* being elevated by the pick 46. Courses 9 are knitted from the

right to the left, the needles moving in the direction indicated by the arrow in the Diagram F, the leading needle at *e* being elevated by the pick **45**. Courses 10 are knitted from the left to the right, Diagram G, the pick **46** raising the leading needle at *f* to the inactive level. Courses 11 are knitted from the right to the left, Diagram H, the leading needle at *g* being elevated to the inactive level by pick **45**. Courses 12 are knitted from the left to the right, Diagram I, the leading needle at *h* being elevated by the pick **46** to the inactive level. As the trailing needles pass the widening pick **47**, the latter moves the three leading needles from the inactive level to the knitting level as at *i* to knit in said courses 12. Courses **13** are knitted from the right to the left, Diagram J, the leading needle at *j* being raised to the inactive level by the pick **45**, the three leading needles at the inactive level being restored to the knitting level as at *k* by pick **47** to knit in said courses 13. Due to the space limitations of the drawings, courses 14 to 17 of the course list are omitted.

Courses 18 are knitted from the left to the right, Diagram K, the leading needle at *l* in this direction of rotation, being elevated by the pick **46**, the three leading needles at the inactive level being restored to the knitting level as at *m* by pick **47** to knit in said courses 18. Courses 19 are knitted from the right to the left, Diagram L, the leading needle at *n* being elevated to the inactive level by the pick **45**, the three leading idle needles being restored to the knitting level as at *o* by the pick **47**, to knit in said courses 19. Courses 20 are knitted from the left to the right, Diagram M. In other words, the courses 20 are knitted by the needles moving in a counterclockwise direction, i. e. in the direction of circular knitting, the needles continuing to move in this direction for the circular courses of the ensuing fabric, i. e., the foot or loopers rounds courses. During this movement of the needles, or the knitting of the first circular courses following the knitting of the heel or toe, the pick **45** elevates the leading needle at *p*, as a consequence of which the yarn Y' has a one-needle lead (Fig. 34 showing a two-needle lead) before being fed into the hooks of the following needles, all inactive level needles being moved to the knitting level to knit in courses 20 and following courses. The lead needle is moved to the knitting level by cam **48** for the following courses.

In Fig. 37 there is shown the loop arrangement along a fragment of a suture line when the picking is as described above. In this view, which may be a fragment of a heel suture, the fabric is knit downwardly and with the leg at the top of the figure and the instep at the right. In this figure, course *ca* is a course knit during narrowing at the second feed when knitting to the right. As this course is completed and knitting is started to the left, the needles knitting wales *w1* and *w2* are lifted out of action and both yarns pass in front of these needles for the knitting of courses *cb* and *cc*. Courses *cd* and *ce* are then made, knitting to the right. As these courses are completed and knitting to the left is started, the needles knitting wales *w3* and *w4* are lifted out of action and both yarns pass in front of these needles for the knitting of courses *cf* and *cg*, knitting to the left.

In the widening, as the course *ci* is knit in the direction of the arrow, the needles which knit wales *w4*, *w3* and *w2* are brought into action and courses *ci* and *cj* are knit on these needles. Upon completion of these courses and reversal of the direction of knitting the needle which knit wale *w2* is raised out of action and both threads pass in front of this needle for the knitting of courses *ck* and *cl*. Previously, the needle which knit wale *w4* was the needle which was raised on the reversal of the direction of knitting. In each case the end needle of the group of needles brought into action was in a different grouping of needles when raised out of action. Thus, the needle which knits wale *w2* was grouped with the needle which knits wale *w1* when raised out of action but is grouped with the needles which knit wales *w4* and *w3* when first brought back into action.

In Fig. 35 there is disclosed another form of picking sequence corresponding to the following course list, the characters of this list giving the same indications as in the previous list.

Course list

Rotary→

← 1	2–
→ 2	2–2
← 3	4–2
→ 4	4–4
← 5	6–4
→ 6	6–6
← 7	8–6
→ 8	8–8
← 9	10–8
→10	10–10
←11	11–10
→12	8–11
←13	9–8
→14	6–9
←15	7–6
→16	4–7
←17	5–4
→18	2–5
←19	3–2
→20	0–3
←21	1–0
→22	→ 1

The last circular course of knitting is indicated at the top of Fig. 35, the knitting proceeding from the left to the right as in Diagram A1. Upon the needles reversing their direction of rotation for the first of the reciprocatory courses of heel or toe knitting, knitting proceeds from the right to the left, Diagram B1, to knit courses 1, the two leading needles at *a'* being elevated to the inactive level by the pick **45**. Reversal of the direction of the movement of the needles causes knitting to proceed from the left to the right, Diagram C1, for courses 2, the two end needles at *b'* being elevated to the inactive level by the pick **46**. The next reverse movement of the needles causes the knitting to proceed from the right to the left, Diagram D1, to knit the courses 3, the two leading needles at *c'* being raised by pick **45**. Due to drawing space limitations, the showing of courses 4 to 9 of the course list has been omitted. Courses 10 are knitted by the needles moving in the direction of the arrow, Diagram E1, the knitting of these courses proceeding from the left to the right, preceding which knitting the pick **46** elevates the two leading needles at *d'* to the inactive level. Courses 11 are then knitted by the needles moving in the direction of the arrow, Diagram F1, knitting proceeding from the right to the left, preceding which knitting the leading needle at *e'* is elevated to the inactive level by pick **45**. Couress 12 are knitted by the needles moving in the direction of the arrow, Diagram G1, the knit-

ting proceeding from the left to the right, preceding which knitting the leading needle at *f'* is elevated to the inactive level by the pick **46**. The three leading inactive needles as at *g'* are brought down by pick **47** and knit during the knitting of the courses. Courses 13 are knitted by the needles moving in the reverse direction, as indicated by the arrow, Diagram H1, knitting proceeding from the right to the left, preceding which knitting the pick **45** elevates the leading needle at *h'* to the inactive level. Pick **47** restores the three leading inactive level needles at as *i'* to knit said courses 13. Again, due to drawing space limitations, courses 14 to 17 inclusive of the course list have been omitted from Fig. 35.

Courses 18 are knitted by the needles moving in the direction of the arrow, Diagram I1, causing the knitting to proceed from the left to the right, preceding which knitting the leading needle at *j'* is elevated to the inactive level by the pick **46**. As the trailing heel needles pass the widening pick **47**, the latter depresses the three leading idle needles as at *k'* to the knitting level, these needles then joining in the knitting of courses 18. Courses 19 are knitted by the needles moving in the reverse direction as indicated by the arrow, Diagram J1, preceding which knitting the pick **45** moves the leading needle at *l'* to the inactive level. As the trailing heel and toe needles pass the widening pick **47**, the latter moves the three leading idle needles as at *m'* to the knitting level. Courses 20 are knitted by the needles moving in the direction of the arrow, Diagram K1, knitting proceeding from the left to the right, preceding which knitting the leading active needle at *n'* is elevated to the inactive level by the pick **46**, the three leading idle needles trailing the active needles being moved down by pick **47** as at *o'* to join in the knitting of these courses. Courses 21 are then knitted by the needles moving in the reverse direction indicated by the arrow, Diagram L1, knitting proceeding from the right to the left, preceding which the pick **45** elevates the leading active needle at *p'* to the inactive level, the three leading idle needles trailing the active needles being moved down by pick **47** as at *r'* to join in the knitting of these courses. The needles then resume circular knitting by moving in the direction of the arrow, Diagram M1, for the knitting of the courses 22 and following circular courses. As the active heel or toe needles pass the pick **46**, the latter elevates the leading heel or toe needle at *s'* to the inactive level to provide a yarn lead for the next following needle, which is the first needle to knit in the courses 22. The single heel or toe needle remaining at the inactive level is picked down by the pick **47** and knits in courses 22. All of the idle needles, including the picked-up lead needle, are then restored to the knitting level by the switch cam **48**.

In Fig. 36 there is disclosed still another picking sequence which varies the appearance of the heels or toes of stockings. The course list follows, the characters of this list giving the same indications as in the previous lists:

Course list

Rotary→	
← 1	2–
→ 2	2–2
← 3	4–2
→ 4	4–4
← 5	6–4

→ 6	6–6
← 7	8–6
→ 8	8–8
← 9	10–8
→10	10–10
←11	13–10
→12	9–13
←13	11–9
→14	7–11
→15	9–7
→16	5–9
←17	7–5
→18	3–7
←19	5–3
→20	1–5
←21	3–1
→22	→ 3

The last circular courses are indicated at the top of the figure, knitting proceeding from the left to the right, the needles moving in a counterclockwise direction as indicated by the arrow, Diagram A2.

Courses 1 are knitted during the first reverse movement of the needles, as indicated by the arrow, Diagram B2, knitting proceeding from the right to the left, preceding which knitting a pick raises the two leading heel or toe needles at a^2 to the inactive level. Courses 2 are knitted by the needles moving in the direction indicated by the arrow, Diagram C2, knitting proceeding from the left to the right, preceding which knitting a pick raises the two leading heel or toe needles at b^2 to the inactive level. Courses 3 are knitted by the needles moving in the reverse direction indicated by the arrow, Diagram D2, knitting proceeding from the right to the left, preceding which knitting a pick raises the two leading heel or toe needles at c^2 to the inactive level. Due to drawing space limitations, courses 4 to 7 of the course list are omitted from the drawings. In comparing the relative number of needles in the courses shown, it should be noted that owing to limitations of space in the drawings two needles are left out on each side at the center in the last rotary courses and in courses 1, 2, 3, 8, 21 and 22 relatively to courses 11 to 15.

Courses 8 are knitted by the needles moving in the direction of the arrow, Diagram E2, knitting proceeding in a direction from the left to the right, preceding which knitting a pick raises the two leading heel or toe needles at d^2 to the inactive level. Again to conserve drawing space, the showing of courses 9 and 10 of the course list is omitted from the drawings.

Courses 11 are knitted by the needles moving in the reverse direction indicated by the arrow, Diagram F2, knitting proceeding from right to left, preceding which knitting a pick raises the three leading heel or toe needles at e^2 to the inactive level. Courses 12 are knitted by the needles moving in the direction of the arrow, Diagram G2, knitting proceeding from the left to the right, preceding which knitting the three leading heel or toe needles at f^2 are raised by a pick to the inactive level. As the active needles pass the widening pick **47**, the latter moves the four leading inactive needles as at g^2 to the knitting level, such needles joining the knitting of courses 12. Courses 13 are knitted by the needles moving in the reverse direction indicated by the arrow, Diagram H2, knitting proceeding from the right to the left, preceding which knitting a pick raises the two leading active heel or toe needles at h^2 to the inactive level. As the trailing active

heel or toe needles pass the widening pick, the latter moves the four leading inactive needles as at i^2 to the knitting level to join in the knitting of courses 13. Courses 14 are knitted by the needles moving in the direction of the arrow, Diagram I2, knitting proceeding from the left to the right, preceding which knitting a pick raises the two leading active, heel or toe needles at j^2 to the inactive level. As the trailing active heel or toe needles pass the widening pick, the latter moves the four leading inactive needles, as at k^2, to a knitting level to join in the knitting of courses 14. Courses 15 are knitted by the needles moving in the reverse direction indicated by the arrow, Diagram J2, knitting proceeding from the right to the left, preceding which knitting a pick raises the two leading active heel or toe needles, at l^2 to the inactive level. As the trailing active heel or toe needles pass the widening pick, the latter engages the four leading inactive needles, as at m^2 and moves them to the knitting level where they join in the knitting of courses 15. Again, due to drawing space limitations, the showing of courses 16 to 20 inclusive has been omitted.

Courses 21 are knitted by the needles moving in the reverse direction indicated by the arrow, Diagram K2, knitting proceeding from the right to the left, preceding which knitting a pick raises two leading, active heel or toe needles at n^2 to the inactive level. As the trailing, active heel or toe needles pass the widening pick, the latter moves the four leading inactive needles, as at o^2 to the knitting level where they join in the knitting of the courses 21. Following the knitting of courses 21, continuous circular knitting is resumed, the needles moving in the direction of the arrow, Diagram L2. Knitting proceeds from left to the right, preceding which knitting a pick elevates the two leading, active heel or toe needles at p^2 to the inactive level to provide a two-needle lead (Fig. 34).

For the following courses all of the needles, including the lead needles, are restored to the knitting level by cam **48** for circular knitting. This includes the last three needles of course 22 to knit, namely, the three needles at the right of this course in Fig. 36.

In Figs. 33, 35 and 36, supplemented by the hereinbefore referred to course lists, there have been disclosed three illustrative picking sequences, each of which differs somewhat from the others in that the resulting construction and characteristics of the heel and/or toe sutures knitted in accordance with these methods vary somewhat. In addition to the three picking sequences specifically disclosed in the drawings, course lists setting forth other picking sequences that modify the construction of the resulting heels and/or toes can be arranged.

While the picking or moving of needles to an inactive level, as hereinbefore described, has been by raising the needles, such needles may be moved to an inactive level by being drawn down below the normal knitting level.

In the foregoing description, the progressive decrease in the number of wales in a narrowed section of a heel or toe and the progressive increase in the number of wales in the widened section thereof are referred to as being relatively staggered or offset. The staggering or offsetting defines a suture line so formed by the variation in the narrowing and widening picking that the needles picked up preparatory to the knitting of a course in the narrowed section are not picked

down in the corresponding course of the widened section. For example, in the narrowed section, if the number of wales is progressively decreased by two for each rotary movement of the needle cylinder, and if the widened section of the pocket is formed by picking down four needles and picking up two needles for each rotary movement of the needle cylinder, the wales of the narrowed and widened sections are not staggered with respect to one another; but, if during the first widened course back and forth reciprocation of the needle cylinder single needles are picked down to knit this course, then the subsequent four and two picking will cause the narrowed and widened wales to be staggered or offset with respect to one another. When staggering or offsetting of the end wales occurs, the group of needles added in the knitting of a widened course divides the group of needles which were narrowed together.

The picking up of two needles at a time results in a float, as indicated in Fig. 34, which floats tend to restrict the elasticity of the fabric. Accordingly, in the widening of the fabric, it is preferable to pick up single needles, as described in connection with the methods of Figs. 33 and 35. Furthermore, if two needles are picked up while the needle cylinder rotates in one direction and the same needles are picked down during a single rotary movement of the needle cylinder, eyelets are formed, due to the spreading of a sinker wale. The formation of eyelets is virtually eliminated by offsetting or staggering the down-picking so that the two needles elevated during one rotary movement of the needle cylinder are restored to the knitting level during different rotary movements of the needle cylinder.

Whenever reference is made to the alternate knitting of the yarns Y and Y', as during the knitting of heels and toes, "alternate" refers to the feeding of each yarn to be knitted in alternate groups of two consecutive courses.

Commonly two or more yarns are fed to the needles of a knitting machine simultaneously and at the same feeding station and knitted into the fabric as a single yarn; in such a case, each of the two or more separate-course yarns herein referred to would consist of the said two or more yarns fed to the needles.

While the stockings may be knitted continuously of two yarns Y and Y', other and heavier yarns may be substituted for said yarns Y and Y', as is customary, to strengthen the heel and toe portions.

While the present invention has been described as pertaining to reciprocatory knitting broadly, the illustrative examples have been directed to the knitting of heels and toes of stockings. Picking sequences similar to those hereinbefore described are applicable to the knitting of so-called split foot or split work fabric wherein opposite sides of a seamless, circular fabric are knitted with two yarns, each yarn constituting one-half, more or less, of the circular fabric, the two threads or yarns being interknitted at opposite sides of the fabric in suture lines. When applied to the knitting of split foot fabric, two separate-course yarns, such as hereinbefore described, are knitted at opposite sides of a knitting machine having, for example, a rotary needle cylinder. In other words, four yarns are knitted during each complete back and forth reciprocation of the needle cylinder, each such yarn being knitted at a separate cam block.

To facilitate looping of the toe a loose course is ordinarily provided. In the present instance

two loose courses are provided in the toe portion of the stocking, one such course being knitted of the yarn Y and the other course being knitted of the yarn Y'. Further to assist in the looping of the toe, one of the yarns, for example the yarn Y, is tinted or treated with a transient dye. In the knitting of the stocking in the manner hereinbefore described, the yarns Y and Y' appear in alternate courses, i. e. a 1 x 1 relation, the circular courses as distinguished from the heel and toe courses. Thus the loose course knitted of the yarn Y' is between two courses knitted of the tinted yarn Y, the first of the said two courses being a normal course and the other course being a loose course. The tinting or dyeing of the yarn Y thus provides two tinted courses of the yarn Y spanning a single course of the yarn Y'. The consequent spanning of the loose course of the yarn Y' provides a contrast, thus facilitating the impaling of the long stitches of the said loose course onto the points of a looper and especially insuring the engagement of points of the looper in the eyelets formed at the ends of the looping.

My copending patent application Serial No. 681,547, filed July 5, 1946, contains claims directed to the method of knitting to facilitate looping, referred to in this paragraph.

While in the foregoing specification there is described the feeding of separate-course yarns to the needles so that two or more threads or yarns are knitted during each revolution of the needle cylinder and during each movement of the needle cylinder in each direction of reciprocatory knitting, it is to be understood wherever in the appended claims reference is made to "a course" or "courses" that a course is knit of the yarn engaged by the needles at each feeding station during each revolution of the needle cylinder and during each movement of the needle cylinder in each direction during reciprocatory knitting. For example, an accordion fabric, under the instant definition, would be constituted by two knitted courses for each rotation or reciprocation of the needle cylinder.

What is claimed is:

1. In a method of knitting heels and toes of stockings, the steps of feeding a plurality of yarns separately to the needles of a knitting machine during reciprocatory knitting so that any one yarn only appears in a recurring group of courses, progressively narrowing and widening the fabric knit by varying, by a group of needles, the needles operated to knit the yarns with each change in the direction of the knitting movement and joining the narrowed and widened sections along suture lines, the varying of the needles operated so relating the narrowing and widening that, in widening, the group of needles added in the knitting of one or more courses divides a group of needles which were narrowed together.

2. In a method of knitting heels and toes of stockings, the steps of feeding two yarns separately to the needles of a knitting machine during reciprocatory knitting so that one of said yarns appears only in alternate groups of courses and the other of said yarns appears only in the intervening groups of courses, progressively narrowing and widening the fabric knit by varying, by a group of needles, the needles operated to knit the yarns with each change in the direction of the knitting movement, varying the extent of the change in the needles during the knitting of both the narrowed and widened sections and joining the narrowed and widened sections along suture lines, the varying of the needles operated so relating the narrowing and widening that, in widening, the end needle of the group of needles added in the knitting of a course is grouped with different needles to those of the group with which it was rendered inactive during narrowing.

3. In a method of knitting heels and toes of stockings, the steps of feeding a plurality of yarns separately to the needles of a knitting machine during reciprocatory knitting so that any one yarn only appears in a recurring group of courses, progressively and continuously narrowing and widening the fabric knit by varying, by a group of needles, the needles operated to knit the yarns with each change in the direction of the knitting movement and joining the narrowed and widened sections along suture lines, the narrowing and widening being so related that in widening the group of needles added in the knitting of one or more courses divides a group of needles which were narrowed together.

4. In a method of knitting heels and toes of stockings, the steps of feeding a plurality of yarns separately to the needles of a knitting machine during reciprocatory knitting so that any one yarn appears only in a recurring group of courses, progressively idling the needles by increments of at least two needles for each rotary movement of the needle cylinder for a plurality of movements and progressively returning the idled needles into action by increments of at least three needles at one end of the active needles while idling a lesser number of needles at the other end during each rotary movement of the needle cylinder for a plurality of movements, the increase and decrease of the active needles interchanging with each change of rotary movement, the idling and returning to action of the needles being so related that, in widening, the end needle of the group of needles added in the knitting of a course is grouped with different needles to those of the group with which it was rendered inactive during narrowing.

5. In a method of knitting heels and toes of stockings with two yarns, each yarn appearing only in alternate groups of at least two courses, the steps of progressively idling a plurality of needles for each rotative movement of the needle cylinder during reciprocatory knitting of a plurality of courses and progressively returning the idle needles for knitting during reciprocatory knitting of a plurality of succeeding courses, the progressive return of the needles for knitting causing at least three needles to resume knitting for each of one or more courses.

6. In a hosiery knitting machine having a rotary needle cylinder with needles independently mounted therein and means for effecting reciprocation of the needle cylinder, means for feeding yarn to the needles at two feeding stations during reciprocatory knitting, picking means for progressively elevating needles in groups to idling position during each back and forth movement of the needle cylinder in the knitting of a plurality of courses and picking means for progressively returning in groups the previously idled needles to knitting during the knitting of a plurality of following courses, the needles knitting both yarns during each movement of the needle cylinder in either direction so that two courses of one yarn alternate with two courses of another yarn and said picking means so relating the needles operated in narrowing and widening that, in widening, the end needle of the group of needles added in the knitting of a course is grouped with different needles to those of the

group with which it was rendered inactive during narrowing.

7. In a method according to claim 1, the varying of the needles operated relating the narrowing and widening in such manner that in a plurality of instances the end stitches of one or more courses in one of said recurring groups of courses in the narrowed section are interknit in the widened section with stitches of a different recurring group of courses.

8. In a method according to claim 1, the varying of the needles operated relating the narrowing and widening in such manner that a needle which knits as a leading end needle in the knitting of a course in the narrowed section knits again as the next to the last needle in the widened section in the course opposite to said narrowed course.

9. In a method according to claim 1, the varying of the needles operated relating the narrowing and widening in such manner that a needle which knits as a leading end needle in the knitting of a course in the narrowed section first knits again as the next to the last needle in the widened section in the course opposite to said narrowed course, and said needle thereafter knits as a leading end needle in the next course in the widened segment.

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Certificate of Correction

Patent No. 2,440,280. April 27, 1948.

ROBERT H. LAWSON

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows: Column 16, line 65, for "the" before the word "knitted" read *be*; column 18, line 74, for "Couress" read *Courses*; column 20, line 10, for "→15" read ←*15*; column 23, line 9, for "relation," read *relation throughout*; line 24, for the indistinct word read *line*; line 50, claim 1, and column 24, line 10, claim 3, for "only appears" read *appears only*; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 13th day of July, A. D. 1948.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.